INVASIVE PLANTS
IDENTIFICATION AND CONTROL
PROFESSIONAL DEVELOPMENT
CONTINUING EDUCATION COURSE

Technical Learning College

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Desert Gold Poppy *Eschscholzia glyptosperma*

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In late 2015 the Environmental Protection Agency issued the long awaited revision to the Worker Protection Standard (WPS). This law it is now technically active and it will be enforced. Please keep in mind that the WPS covers both restricted use AND general use pesticides. This course is not for worker and/or handler training. Always follow the label and your State Pesticide Agency rules.

Important Information about this Manual

This CEU course manual has been prepared to educate pesticide applicators and operators in general safety awareness of dealing with the often-complex and various pesticide treatment devices, methods, and applications.

This manual covers general laws, regulations, required procedures, and accepted policies relating to the use of pesticides. It should be noted, however, that the regulation of pesticides and hazardous materials is an ongoing process and subject to change over time. For this reason, a list of resources is provided to assist in obtaining the most up-to-date information on various subjects.

This manual is not a guidance document for applicators or operators who are involved with pesticides. It is not designed to meet the requirements of the United States Environmental Protection Agency or your local State environmental protection agency or health department.

This CEU course manual provides general pesticide safety awareness and should not be used as a basis for pesticide treatment method/device guidance. This document is not a detailed pesticide information resource or a source or remedy for poison control.

Technical Learning College or Technical Learning Consultants, Inc. make no warranty, guarantee or representation as to the absolute correctness or appropriateness of the information in this manual and assumes no responsibility in connection with the implementation of this information. It cannot be assumed that this manual contains all measures and concepts required for specific conditions or circumstances. This document is to be used solely for educational purposes only and is not considered a legal document.

Pesticides are poisonous. Always read and carefully follow all precautions and safety recommendations given on the container label. Store all chemicals in the original labeled containers in a locked cabinet or shed, away from food or feeds, and out of the reach of children, unauthorized persons, pets, and livestock.

Confine chemicals to the property being treated. Avoid drift onto neighboring properties, especially gardens containing fruits and/or vegetables.

Dispose of empty containers carefully. Follow label instructions for disposal. Never reuse containers. Make sure empty containers are not accessible to children or animals.

Never dispose of containers where they may contaminate water supplies or natural waterways.

Do not pour down sink or toilet. Consult your county agricultural commissioner for correct ways of disposing of excess pesticides. Never burn pesticide containers.

Individuals who are responsible for pesticide storage, mixing, and application should obtain and comply with the most recent federal, state, and local regulations relevant to these sites and are urged to consult with the EPA and other appropriate federal, state, and local agencies.

Copyright Notice

Precept-Based Training CEU Course

This training course is made of "micro-content" or "precepts"– small chunks of information that can be easily digested. Using bite-size pieces of technical information is considered to be one of the most effective ways of teaching people new information because it helps the student to retain knowledge easier.

Micro-learning or precept-based training doesn't rely on the student to process a large amount of information before breaking it down. Our method includes short modules with clearly defined learning goals for each section. This method allows a student to hone in on a particular skill, then demonstrate their knowledge in the final assessment.

States and employers require the final exam to be proctored.

2017 Changes to EPA's Worker Protection Standard

This course contains EPA's federal rule requirements. Please be aware that each state implements pesticide regulations that may be more stringent than EPA's regulations and these frequently are changed. Check with your state environmental/pesticide agency for more information.

Technical Learning College's Scope and Function

Welcome to the Program,

Technical Learning College (TLC) offers affordable continuing education for today's working professionals who need to maintain licenses or certifications. TLC holds several different governmental agency approvals for granting of continuing education credit.

TLC's delivery method of continuing education can include traditional types of classroom lectures and distance-based courses or independent study. TLC's distance-based or independent study courses are offered in a print - based distance educational format. We will beat any other training competitor's price for the same CEU material or classroom training.

Our courses are designed to be flexible and for you to finish the material at your convenience. Students can receive course materials through the mail or electronically. The CEU course or e-manual will contain all your lessons, activities and instruction to obtain the assignments. All of TLC's CEU courses allow students to submit assignments using e-mail or fax, or by postal mail. (See the course description for more information.)

Students have direct contact with their instructor—primarily by e-mail or telephone. TLC's CEU courses may use such technologies as the World Wide Web, e-mail, CD-ROMs, videotapes and hard copies. (See the course description.) Make sure you have access to the necessary equipment before enrolling; i.e., printer, Microsoft Word and/or Adobe Acrobat Reader. Some courses may require proctored closed-book exams, depending upon your state or employer requirements.

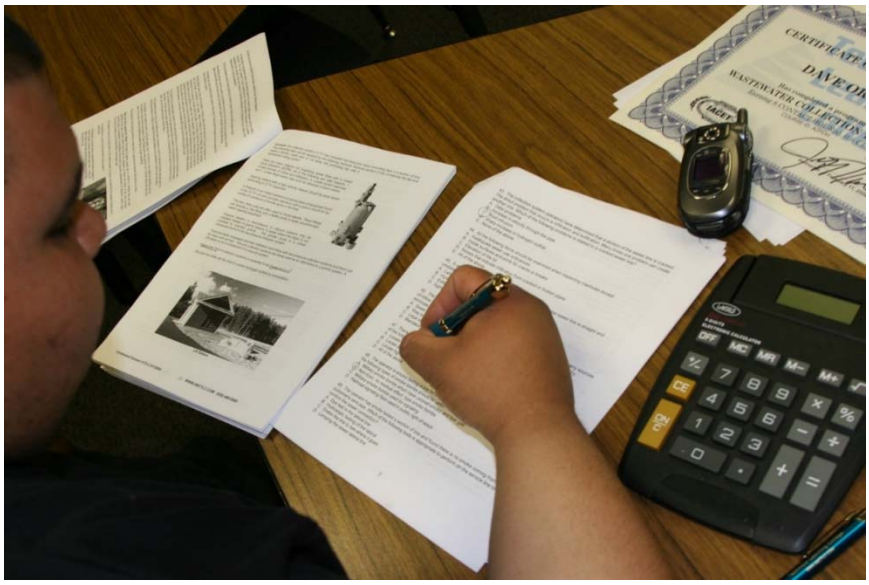
Flexible Learning
At TLC, there are no scheduled online sessions or passwords you need contend with, nor are you required to participate in learning teams or groups designed for the "typical" younger campus - based student. You will work at your own pace, completing assignments in time frames that work best for you. TLC's method of flexible individualized instruction is designed to provide each student the guidance and support needed for successful course completion.

Course Structure
TLC's online courses combine the best of online delivery and traditional university textbooks. You can easily find the course syllabus, course content, assignments, and the post-exam (Assignment). This student-friendly course design allows you the most flexibility in choosing when and where you will study.

Classroom of One
TLC offers you the best of both worlds. You learn on your own terms, on your own time, but you are never on your own. Once enrolled, you will be assigned a personal Student Service Representative who works with you on an individualized basis throughout your program of study. Course specific faculty members (S.M.E.) are assigned at the beginning of each course providing the academic support you need to successfully complete each course. Please call or email us for assistance.

No Data Mining Policy
Unlike most online training providers, we do not use passwords or will upload intrusive data mining software onto your computer. We do not use any type of artificial intelligence in our program. Nor will we sell you any other product or sell your data to others as with many of our competitors. Unlike our training competitors, we have a telephone and we humanly answer.

Satisfaction Guaranteed
We have many years of experience, dealing with thousands of students. We assure you, our customer satisfaction is second to none. This is one reason we have taught more than 20,000 students.



We welcome you to do the electronic version of the assignment and submit the answer key and registration to us either by fax or e-mail. If you need this assignment graded and a certificate of completion within a 48-hour turn around, prepare to pay an additional rush charge of $50.

We welcome you to complete the assignment in Word.

Once we grade it, we will mail a certificate of completion to you. Call us if you need any help.

Contact Numbers
Fax (928) 468-0675
Email Info@tlch2o.com
Telephone (866) 557-1746

Invasive Plant Identification and Control CEU Training Course
Course Description

Welcome to the world of invasive and exotic plant identification and control. The purpose of this course is to help you learn about the highly specialized area of terrestrial pest management. Only by being properly prepared can you expect to perform your duties safely and effectively.

As a member of the plant/landscaping/weed application industry, you need to develop the knowledge and skills to recognize:
- If an organism is a pest.
- What caused the pest to become a nuisance?
- The life cycle of the pest.
- Which life stage of the pest is susceptible to your management strategies.
- Various management techniques and tools, including pesticides, suitable for aquatic uses.
- How nontarget organisms may react to a proposed management strategy.
- The changing conditions of the aquatic environment in which you work.

This course covers diverse topics relating to plant biology including morphology, anatomy, physiology, ecology, systematics, and the evolution of terrestrial plants. The course enables a field-oriented study of ecological concepts and provides an opportunity to learn collecting techniques, specimen handling, development of skills for identifying common terrestrial species and chemical, biological and mechanical control of plants. This course will also cover common herbicide usage, integrated pest management, and pesticide/herbicide regulations.

This continuing education course was designed as a quick and ready reference of invasive/ exotic/weed control practices used in various landscaping/cropping systems or site/situations. Because chemical regulation of plant growth is complex and requires considerable knowledge, a large portion of the course is devoted to registered uses of herbicides, weed identification, and pesticide use regulation. In all cases, the authors make every effort to list only registered herbicides and to ensure that the information conforms to product labels and company recommendations.

The California Invasive Plant Inventory categorizes non-native invasive plants that threaten the state's wildlands. Categorization is based on an assessment of the ecological impacts of each plant. The Inventory represents the best available knowledge of invasive plant experts in the state; hopefully the Student can learn how to properly identify and control invasive and exotic plants.

California is home to 4,200 native plant species, and is recognized internationally as a "biodiversity hotspot." Approximately 1,800 non-native plants also grow in the wild in the state. A small number of these, approximately 200, are the ones that this Inventory considers invasive and this course will focus upon. The course author Melissa Durbin hopes to improve an understanding of these impacts and to help those working to protect California's treasured biodiversity.

The Invasive PIant Inventory categorizes plants as High, Moderate, or Limited, reflecting the level of each species' negative ecological impact in California. Other factors, such as difficulty of management or will identified in this course or in your assignment. It is important to note that even Limited species are invasive and should be of concern to land managers. Although the impact of each plant varies regionally, its rating represents cumulative impacts statewide. Therefore, a plant whose statewide impacts are categorized as Limited may have more severe impacts in a particular region. Conversely, a plant categorized as having a High cumulative impact across California may have very little impact in some regions.

The Inventory categorizes "invasive non-native plants that threaten wildlands" according to the definitions below. Plants were evaluated only if they invade California wildlands with native habitat values. The Inventory does not include plants found solely in areas of human-caused disturbance such as roadsides and cultivated agricultural fields.

- *Wildlands* are public and private lands that support native ecosystems, including some working landscapes such as grazed rangeland and active timberland.
- *Non-native plants* are species introduced to California after European contact and as a direct or indirect result of human activity.
- *Invasive non-native plants that threaten wildlands* are plants that 1) are not native to, yet can spread into, wildland ecosystems, and that also 2) displace native species, hybridize with native species, alter biological communities, or alter ecosystem processes.

This course is designed for personnel:

- That need Pesticide/Herbicide Applicator continuing education for categories such as:
  - Aquatic
  - Right-of-Way
  - General Standards (CORE)
  - Aerial
  - Ornamental and Turf
- Who are employed in plant management and need continuing education credit.
- That are responsible for terrestrial/aquatic weed control in right-of- ways, around lakes, golf course, along rivers, parks, and in residential developments.
- That operate and calibrate herbicide and pesticide application equipment.

- That are employed by a public agency or private company which is responsible for vegetation management along right-of-ways and in natural areas.
- Who use biological control techniques to suppress plant or weed growth.

Caution!

This handbook is not intended as a complete guide to herbicide use. Before using any chemical, you must read the label on the container. Before a chemical can be recommended for a specific use, it must be thoroughly tested. Information is supplied here with the understanding that no discrimination is intended and no endorsement by Technical Learning College is implied. Due to constantly changing laws and regulations, the authors can assume no liability for the recommendations. Any use of a pesticide contrary to instructions on the printed label is not legal or recommended.

Course Procedures for Registration and Support

All of Technical Learning College's correspondence courses have complete registration and support services offered. Delivery of services will include, e-mail, web site, telephone, fax and mail support. TLC will attempt immediate and prompt service. All students will be tracked by an unique number assigned to the student.

Instructions for Written Assignments

The Invasive Plant Identification and Control training distance learning course uses a multiple choice style answer key. You can write your answers in the answer key inside the assignment or type out your own answer key. TLC would prefer that you type out and e-mail the examination to TLC, but it is not required. Please find the assignment and registration page on TLC's website. There is also an alternative CEU course practicum assignment available, contact your Instructor for further instruction and permission.

Feedback Mechanism (examination procedures)

Each student will receive a feedback form as part of his or her study packet. You will be able to find this form in the front of the assignment attachment.

Security and Integrity

All students are required to do their own work. All lesson sheets and final exams are not returned to the student to discourage sharing of answers. Any fraud or deceit and the student will forfeit all fees and the appropriate agency will be notified.

Grading Criteria

TLC will offer the student either pass/fail or a standard letter grading assignment. If TLC is not notified, you will only receive a pass/fail notice.

Required Texts

The course will not require any other materials. This course comes complete.

Pesticide and Herbicide Terms, Abbreviations, and Acronyms

TLC provides a glossary that defines in non-technical language commonly used pesticide and herbicide terms appearing in publications and materials. It also explains abbreviations and acronyms used throughout the EPA and other governmental agencies. You can find the glossary in the rear of this manual.

Recordkeeping and Reporting Practices
TLC will keep all student records for a minimum of five years. It is your responsibility to give the completion certificate to the appropriate agencies. TLC will complete and return to you the forms necessary for your certificate renewal.

ADA Compliance
TLC will make reasonable accommodations for persons with documented disabilities. Students should notify TLC and their instructors of any special needs. Course content may vary from this outline to meet the needs of this particular group. There is also an alternative CEU course practicum assignment available, contact your Instructor for further instruction and permission.

Note to students: Keep a copy of everything that you submit. If your work is lost you can submit your copy for grading. If you do not receive your graded assignment or quiz results within two or three weeks after submitting, please contact your instructor. We expect every student to produce his/her original, independent work. Any student whose work indicates a violation of the Academic Misconduct Policy (cheating, plagiarism) can expect penalties as specified in the Student Handbook, which is available through Student Services; contact them at (928) 468-0665. You will have 90 days from receipt of this manual to complete it in order to receive your Continuing Education Units (**CEUs**) or Professional Development Hours (**PDHs**).

A score of 70% or better is necessary to pass this course. If you should need any assistance, please email all concerns or call us. If possible e-mail the final test to info@tlch2o.com or fax (928) 468-0675.

Course Objective: To provide continuing education training in invasive and exotic plant identification, weed control, effective, safe herbicide applications, biological, mechanical treatment methods and management strategies.

Educational Mission
The educational mission of TLC is:

To provide TLC students with comprehensive and ongoing training in the theory and skills needed for the pesticide application field,

To provide TLC students with opportunities to apply and understand the theory and skills needed for operator certification,

To provide opportunities for TLC students to learn and practice environmental educational skills with members of the community for the purpose of sharing diverse perspectives and experience,

To provide a forum in which students can exchange experiences and ideas related to pesticide education,

To provide a forum for the collection and dissemination of current information related to pesticide education, and to maintain an environment that nurtures academic and personal growth.

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Common Weed Identification Terms

Alternate- Leaves that are arranged singly up the stem; not opposite each other.
Annual- Plant that germinates, flowers, seeds, and dies during one growing season.
Anther- Structure in a flower in which pollen is formed
Auricle- Lobe-like structure at the collar of a grass leaf.
Awn- Slender bristle at the tip of grass seed structures.
Axil- The angle formed between a leaf and a stem.
Basal- At the base of a plant or plant part.
Biennial- Plant that germinates in one growing season, then flowers, seeds, and dies during the next year.
Bract- Leaf-like structure at the base of flowers or leaves.
Calyx- All the flower leaves together, normally green in color.
Clasping leaves- Leaves that appear to wrap around the stem at their base.
Compound leaves- Leaves with 2 or more distinct leaflets.
Cotyledons- The first leaf-like structures that appear after germination; seed leaves.
Crown- The structure formed where leaves, stems, and roots grow together.
Dissected- Deeply and repeatedly divided into smaller parts.
Entire- Not toothed or otherwise cut.
Glumes- The 2 bracts surrounding a grass spikelet.
Head- A group of flowers borne tightly together.
Leaflets- Leaf-like structures within a compound leaf.
Ligule- The structure at the collar of a grass leaf between the sheath and the stem.
Linear- Long, narrow, and slender.
Lobed- A cut into a leaf from the edge toward the center; greater than toothed, but not quite compound.
Margin- The edge of a leaf.
Membranous- Thin and flexible, usually not green.
Midrib- The center and usually most prominent vein on a leaf.
Nodding- A flower that is not pointed upward, but bent downward or sidewise to the stem.
Opposite- Leaves situated directly across the stem from each other.
Ovate- Egg shaped in outline.
Panicle- A much-branched inflorescence.
Perennial- A plant that lives for more than 2 growing seasons.
Petiole- A leaf stalk.
Pinnate- With 2 rows of leaflets, like a feather.
Plume- A hair-like or feather-like structure, often on a seed.
Pubescence- The hairs on a leaf, stem or flower.
Rhizome- A creeping, underground stem.
Rosette- A circular, normally basal, clump of leaves.
Sheath- The extension of leaf tissue surrounding a stem.
Simple leaf- One with a blade in one piece; not compound.
Spike- A narrow, non-spreading inflorescence.
Spikelet- A single or group of floral structures in a grass.
Spur- A hollow appendage on a flower.
Stolon- A creeping stem along the surface of the ground.
Succulent- Fleshy and juicy.
Taproot- A thick, central root with minimal branching.
Trifoliate leaf- A leaf made of 3 leaflets; clover-like.
Whorled- 3 or more similar structured arranged as spokes on a wheel.

Plant / Animal Abbreviations

A - Adjective
alt. - alternative name (synonym)
AS. - Anglo-Saxon
Comb. Form. - Combining form
Dan. - Danish
Dim. - diminutive
E. - English
esp. - especially
Fr. - French
fr. - from
G. - German
Gael. - Gaelic
Goth. - gothic
Gr. - Greek
Icel. - Icelandic
i.e. - for example
Ir. - Irish
It. - Italian
L. - Latin
LL. - Low Latin, Late Latin
MD. - Middle Dutch
ME. - Middle English
n. - noun
NL. - New Latin
OE. - Old English
O.Fr. - Old French
OHG. - Old High German
ON. - Old Norse
perh. - perhaps
pl. - plural
pp. - past participle
prob. - probably
pres. part. - Present participle
Scand. - Scandinavian
Skt. - Sanskrit
Sp. - Spanish
specif. - specifically
Sw. - Swedish
vt. - verb transitive
W. - Welsh

Topic 1 Weed Identification Introduction Section

A weed is any plant growing in an area where it is not wanted. We try to control weeds because they compete with crops for light, moisture, space and nutrients. Certain weed species can harbor plant diseases and insect pests and can be a serious threat to the ecosystem's health. Other species may be poisonous, allergenic or an irritant to humans and/or livestock. Medical and economic problems such as illness, death, rash, hayfever, or a reduction in quality of fur, meat and milk products may result.

Weeds have many unique characteristics which make them extremely difficult to control. Most produce a tremendous number of seeds. The seeds of some weed species may be dormant for many years, with only a small percentage germinating each year. Some seeds will not germinate without intense heat, like from a wild fire. Weeds generally mature earlier than the crop and often seeds will be dropped before crop harvest and remain in the field. Weeds are generally more competitive than crops and can often survive under unfavorable growing conditions.

Weeds may conveniently be divided into two classes based on the way in which they emerge from the seed. Monocots emerge with a single seed leaf whereas dicots emerge with two seed leaves. Most monocot weeds found in turfgrass are from the family Gramineae and are termed **weedy grasses**. Examples include crabgrass, annual bluegrass, tall fescue, and quackgrass. Dicots, on the other hand, are termed **broadleaf weeds** and include such plants as dandelion, clover, ground ivy, knotweed, and plantain.

Weedy grasses and broadleaf weeds are further divided into groups according to the plants' length of life. **Perennial weeds** have a life of more than two years, though new seeds may be produced every year. **Biennial weeds** have a life of two years, generally storing up food reserves in the leaves and roots the first year and producing seed in the second year. The biennial weeds are often grouped with perennial weeds since control is similar.

Annual weeds germinate from seed, grow, flower, and produce seed in less than one year. **Summer annuals (AKA warm season annuals)** germinate in the spring and mature in the fall, whereas **winter annuals (AKA cool season annuals)** germinate in fall or late winter and mature in late spring.

Summer annuals complete their lifecycle from seed to maturity in less than one year. They germinate in the spring, mature, set seed and die in the fall. Winter annuals germinate in the fall, overwinter as seedlings or small rosettes and mature, set seed and die the following spring or early summer. Some weeds are capable of both summer and winter annual lifecycles.

Biennials
Biennials complete their lifecycles in less than two years. Germination and the production of an overwintering rosette of leaves occur the first year. The second year flowering, seed production, and plant death occur. Control is best obtained during the first year.

Perennials
Perennials live for more than two years. They reproduce vegetatively from roots, rhizomes, buds, or tillers, or from seed, or both. They can be especially difficult to control because of their persistent root systems.

Early identification of emerged weed species is critical for choosing the best weed control methods. This guide will enable you to identify weeds at three growth stages.

Effective control of weeds in turf is based on correct identification. Many books and charts are available to help in identifying common lawn weeds. For additional help in weed identification, inquire at your county extension service.

What is a Weed?

Generally, the term weed is used to describe any plant that is unwanted and grows or spreads aggressively. Terms such as invasive, exotic or non-native are used somewhat interchangeably to refer to weeds that infest large areas. Free from the natural controls present in their native lands, these weeds grow quickly and overtake native plants.

Noxious Weed
Millions of acres of once healthy, productive rangelands, forestlands and riparian areas have been overrun by noxious or invasive weeds. They are invading recreation areas, public lands, National Parks, State Parks, roadsides, stream banks, Federal, state, and private lands.

Invasive or Noxious Weeds:

- destroy wildlife habitat
- reduce opportunities for hunting, fishing, camping, and other recreational activities
- displace many Threatened and Endangered Species
- reduce plant and animal diversity because of weed monocultures-single plant species that over-run all others in an area
- disrupt waterfowl and neo-tropical migratory bird flight patterns and nesting habitats
- cost millions of dollars in treatment and loss of productivity to private land owners.

What is a Noxious Weed?
The term "weed" means different things to different people. In the broadest sense, it is any plant growing where it is not wanted. Weeds can be native or non-native, invasive or non-invasive, and noxious or not noxious. Legally, a noxious weed is any plant designated by a Federal, State or county government as injurious to public health, agriculture, recreation, wildlife or property. (Sheley, Petroff, and Borman,1999) A noxious weed is also commonly defined as a plant that grows out of place (i.e. a rose can be a weed in a wheat field) and is "competitive, persistent, and pernicious." (James, et al, 1991).

The noxious weeds mandated for control are plants non-native to North America. Consequently, these plants do not have the natural checks as found in their native land, such as insects, diseases, and herbivores that would keep the plant population in check. Due to the competitive aggressive ability of these plants, coupled with no natural controls, these plants will develop mono-culture stands. Not only are many crops out competed by these weeds, but native vegetation and the wildlife associated with it will be replaced. Consequently, identifying the weeds when they first become established and developing an integrated weed management plan to control them is critical in maintaining healthy, productive land. The term noxious weed is used to describe a legal designation for plant species that have been determined to be especially undesirable or difficult to control. These weeds are subject, by law, to certain restrictions. Regulated by the U.S. Department of Agriculture, there are 90 federal noxious weeds. Please see the Federal Listing of Noxious and Alien weeds in the rear of this course for more information.

Are invasive plants the same as noxious weeds?
No. Invasive plants include not only noxious weeds, but also other plants that are not native to this country. Plants are considered invasive if they have been introduced into an environment where they did not evolve. As a result, they usually have no natural enemies to limit their reproduction and spread (Westbrooks, 1998). Some invasive plants can produce significant changes to vegetation, composition, structure, or ecosystem function. (Cronk and Fuller, 1995).

What is an Invasive Species?
An 'invasive species' is defined as a species that is 1) non-native (or alien) to the ecosystem under consideration and 2) whose introduction causes or is likely to cause economic or environmental harm or harm to human health. (Executive Order 13112).

Understanding Weed Terms

Biodiversity: Biodiversity is, simply put, all life on earth, even that which has yet to be discovered. More specifically, it includes the millions* of diverse species, from bacteria to whales, that share the earth's lands and waters with us. Each year, many thousands of species are being extinguished as a result of human activities, such as habitat destruction and exotic species introductions.

- *The actual number of species in existence is unknown and can only be estimated because we really only know about the species that botanists, entomologists and other scientists have been able to collect, process and identify to date.

Biological Management: Biological control is the deliberate use of the pest's natural enemies - predators, parasites, and pathogens - to reduce the pest population below damage levels.

Chemical Control: When exploring chemical control options, you should select the lowest risk and most effective products. The key is to use pesticides in a way that complements rather than hinders other elements in the strategy and which also limits negative environmental effects. It is important to understand the life cycle of a pest so that the pesticide can be applied when the pest is at its most vulnerable – the aim is to achieve maximum effect at minimum levels of pesticide.

Cultivar: Short for “cultivated variety.” A plant “variety” developed by man via plant selection and/or genetic manipulation to exhibit a set of plant characteristics. Cultivars are maintained via controlled pollination or vegetative means, so that cultivar characteristics are passed to ensuing generations.

Cultural management: Cultural practices are a manipulation of the habitat environment to increase pest mortality or reduce rates of pest increase and damage. There are many different cultural practices that can help to reduce pest impact such as selection of pest resistant varieties of crops, mulching, winter cover crops, changing planting dates to minimize insect impact, burning, flooding, crop rotations that include non-susceptible crops, moisture management, addition of beneficial insect habitat, or other habitat alterations.

Ecovar: Short for “ecological variety.” A plant “variety” developed by man from a collection of plants of a native species that were selected from several to many natural populations in a specific region. The purpose is to have high genetic diversity in the parent collection, which reflects the natural diversity within that species in the defined region. To maintain genetic diversity in ensuing generations, little to no selection is done during the ecovar development process. An ecovar is an intermediate step between a wild-growing plant and a cultivar.

Exotic (introduced) plant: A plant species that exists in a region because it was brought to that region by man, during and since settlement of the region. We are still introducing exotic plants, by intention or by accident.

Exotic invasive plant: An exotic plant species that is able to invade and overrun native ecosystems. Some native plants can become invasive under certain conditions, but most invasive species are introduced (exotic).

Growth Habit – Invasiveness: The most important aspect of an alien plant is how it responds to a new environment. An invasive species is one that displays rapid growth and spread, allowing it to establish over large areas. Free from the vast and complex array of natural controls present in their native lands, including herbivores, parasites, and diseases, exotic plants may experience rapid and unrestricted growth in new environments. Invasiveness is enhanced by features such as strong vegetative growth, abundant seed production, high seed germination rate, long-lived seeds, and rapid maturation to a sexually reproductive (seed-producing) stage. Invasive plants reproduce rapidly, either vegetatively or by seed. Their phenomenal growth allows them to overwhelm and displace existing vegetation and form dense one-species stands.

Not all exotic species are considered harmful. For example, a small number of non-invasive alien plants (e.g., corn, wheat, oats) form the basis of our agricultural industry and pose little to no threat to our natural ecosystems. However, each alien plant is one less native host plant for our native insects, vertebrates and other organisms that are dependent upon them.

Ornamental plant: A plant species or cultivar that is grown for its beauty (in its end use), rather than commercial or production reasons.

Integrated Pest Management (IPM): Is a comprehensive, environmentally sensitive approach to managing pests that includes a combination of strategies that pose the least hazard to people, property, and the environment. The simple philosophy is that control will be more effective, and resistance will be less likely to build up, when a range of measures is deployed against a pest. These measures can include, cultural, mechanical or physical, biological, and chemical methods for managing the pest.

Some of the key components to a successful IPM program include the following:

- Identify current and potential pest species, their biology, and conditions conducive to the pest(s) (air, water, food, shelter, temperature and light).
- Understand the physical and biological f actors that affect the number and distribution of pests and their natural enemies.
- Conserve natural enemies.
- Prevent, Avoid, and Monitor potential pest species.
- Establish “Action Thresholds” (such as a certain number of pests per acre) at which point an approved management strategy will be implemented.
- Review available Tools and Best Management Practices for the management of the identified pest(s).

Tools can include:
1) No action. This alternative may be chosen if the pest numbers are low enough that they don't interfere with management goals;
2) Physical (manual & mechanical) management;
3) Cultural management;
4) Biological management; and,
5) Chemical management strategies.

- Select the most effective, low risk pest management strategies in accordance with applicable laws, regulations, and policies.
- Build consensus with stakeholders-occupants, decision-makers and technical experts (ongoing throughout the process).
- Document decisions and maintain records.
- Obtain approval, define responsibilities and implement selected best management strategies.
- Evaluate results of management strategies; determine if objectives have been achieved; modify strategy if necessary.

The pest issues affecting Service trust resources are broad and complex. The competition and predation of nonnative species poses risks to approximately 50% of threatened and endangered species. Some of the top pest issues affecting Service trust resources include the Norway rat, arctic fox, northern pike, European starling, European green crab, Chinese mitten crab, Canada and musk thistle, purple loosestrife, saltcedar (tamarisk), Chinese tallow tree, Russian knapweed, spotted knapweed, buffel grass, ox-eye daisy, orange hawkweed, Johnson grass, field bindweed, leafy spurge, Russian olive, Dalmatian and yellow toadflax, salvinia molesta, and soybean aphid.

Mechanical or Physical Management: Mechanical or physical control methods involve using barriers, traps, or physical removal to prevent or reduce pest problems. Tactics may include using row covers or trenches to prevent insects from reaching the crop, baited or pheromone traps to capture insects, or cultivation or mowing for weed control.

Native plant: A plant species that is found in a region because it developed and evolved in that region over thousands of years. Plants that existed in a region prior to settlement.

Naturalized plant: An exotic plant that was introduced into an area, escaped from cultivation and reproduces on its own (includes exotic invasive plants). Many plants commonly thought to be natives were actually introduced by early settlers.

Noxious Weeds: The term noxious is a legal designation used specifically for plant species that have been determined to be major pests of agricultural ecosystems and are subject, by law, to certain restrictions. The U.S. Department of Agriculture regulates noxious weeds. Plants can also be designated as "noxious weeds" by states and counties, usually through "noxious weed boards". Many noxious weeds designated for their impacts to agriculture also threaten natural areas. Melaleuca (Melaleuca quinquen-ervia), a tree from Australia, aggressively invades seasonal wetlands in the Everglades National Park in Florida and has been designated a federal noxious weed. Additional listings of exotic pest plants affecting natural ecosystems are expected, as their ecological and economic impacts continue to grow.

Pest: Any living organism (plant or animal) that occurs where it is not wanted or that causes damage to crops or humans or other animals.

Source-identified seed: Off-spring of plants collected from a single defined natural population of a native species for production of seed. No selection is done during the collection and subsequent seed increase steps, so as to conserve genetic diversity. The genetic diversity is less than for an ecovar.

Variety: Within a species, a naturally occurring sub-group of plants that have one or more minor characteristics that set it apart from the rest of the species. Ex.: Solidago odora var. chapmanii.

Weeds, Wildlands and Natural Areas: The term weed is a subjective word used to describe any plant considered to be "out of place." In other words, weeds can include native and non-native plants alike, growing wherever someone wishes they weren't. Invasive exotic plants of natural ecosystems are often referred to as natural areas weeds. A natural area is generally an area of land or water with predominantly native vegetation or natural geological features that is allowed to respond to the forces of nature with little to no direct human interference. The term wildlands is also used to describe these areas.

Field Bindweed

Recognize the major plant characteristics used to identify weeds.

Auricle- An appendage that grows from the edge of the collar and may wrap around the stem.

Blade- The upper part of the leaf.

Collar- Located where the blade and the sheath meet.

Crown- Region of nodes with tightly compacted internodes.

Internode- The region between the nodes.

Ligule- A structure that grows from the collar area on the inner side of the leaf.

Node- Enlarged areas at intervals along the stem and also the part of the plant where buds are attached.

Rhizomes- Underground stems that grow laterally.

Roots- Attachment of the plant to the soil that absorbs minerals and water needed for the plants survival.

Sheath- Lower part of the leaf that is attached to the node.

Shoot- The aboveground parts of the plant.

Stolons- Aboveground stems that grow laterally.

Vernation- Characteristic of the grass that describes how the new blades emerge from the sheath as growth occurs.

The Invasive Problem

Invasive Species

The term “native” is used to describe plants that were growing here before the arrival of Europeans. Exotics are those that do not naturally occur in an area but have been introduced by people. Many exotic species pose no threat, but some are invasive and grow out of control — displacing native plants which provide food and shelter for an assortment of native wildlife. Unfortunately, it is not always possible to predict if or when a species will become a pest plant (for example, Japanese honeysuckle was planted as an ornamental for 80 years before it escaped cultivation!), but a red flag should run up at any non-native with fleshy fruits dispersed by birds.

Impacts of Invasive Alien Plants

Invasive non-native organisms are one of the greatest threats to the natural ecosystems of the U.S. and are destroying America's natural history and identity. These unwelcome plants, insects and other organisms are disrupting the ecology of natural ecosystems, displacing native plant and animal species, and degrading our nation's unique and diverse biological resources. Aggressive invaders reduce the amount of light, water; nutrients and space available to native species, alter hydrological patterns, soil chemistry, moisture-holding capacity, and erodibility, and change fire regimes (Randall 1996). Some exotics are capable of hybridizing with native plant relatives, resulting in unnatural changes to a plant's genetic makeup; others have been found to harbor plant pathogens, such as bacterial leaf scorch (Xylella fastidiosa) that can affect both native and non-native plants, including ornamentals (McElrone, et al., 1999). Still others contain toxins that may be lethal to certain animals. For example, garlic mustard has been found to contain compounds that are lethal to a native butterfly species.

Exotic organisms have been referred to as biological pollution (Westbrooks 1991). In some cases, exotic plant invaders are driving our rarest species closer to extinction. According to the U.S. Fish and Wildlife Service, an estimated 42% of the nation's endangered and threatened species have declined as a result of encroaching exotic plants and animals. And management of these species is expensive. Each year, the National Park Service and the Fish and Wildlife Service spend an estimated 2 and 10 million dollars, respectively, on controlling exotic plants (Westbrooks, 1998). Invasive plants also cause great economic losses and expenditures each year, measured in billions of dollars, for agriculture, forestry, range lands and roadways management (Westbrooks 1998).

Impacts to Native Fauna

Our native fauna, including insects, birds, mammals, reptiles, fish and other animals, is dependent on native plants for food and shelter. While some animals have a varied diet and can feed on a wide number of plant species, others are highly specialized and may be restricted to feeding on several or a single plant species. For example, caterpillars of the monarch butterfly have evolved to feed primarily on plants in the genus Asclepias (milkweeds) that contain special chemicals. The term host plant is generally used to describe a plant species that is required food for at least one stage of an insect or other animal. As exotic plants replace our native flora, fewer host plants are available to provide the necessary nutrition for our native wildlife.

Approximately 4,000 species of exotic plants (Kartesz and Morse 1997) and 500 exotic animals (Office of Technology Assessment 1993) have established free-living populations in the United States. Nearly seven hundred are known to cause severe harm to agriculture at a cost of billions of dollars annually. Over 1,000 exotic plant species have been identified as a threat to our native flora and fauna as a result of their aggressive, invasive characteristics.

Some of the known ecological impacts of invasive plants are summarized below, and include:

- ✓ Alterations to the frequency and intensity of natural fires.
- ✓ Changes to natural ecological processes such as plant community succession.
- ✓ Disruption of native plant-animal associations such as pollination, seed dispersal and host-plant relationships.
- ✓ Loss of and encroachment upon endangered and threatened species and their habitat.

- ✓ Loss of food sources for wildlife.
- ✓ Loss of habitat for native insects, birds, and other wildlife.
- ✓ Reduction of biodiversity

Invasive Alien Plants

- ✓ Alter hydrological flows and conditions.
- ✓ Change characteristics of the soil structure and chemistry.
- ✓ Compete with and replace rare and endangered species.
- ✓ Disrupt insect-plant associations necessary for seed dispersal of native plants.
- ✓ Disrupt native plant-pollinator relationships.
- ✓ Encroach upon limited habitat of rare and endangered species.
- ✓ Hybridize with native plant species, altering their genetic makeup.
- ✓ Increase erosion along stream banks, shorelines and roadsides.
- ✓ Increase the incidence of plant disease and stress in forested areas.
- ✓ Kill trees and shrubs through girdling.
- ✓ Prevent seedling establishment of native trees and shrubs.
- ✓ Reduce and eliminate host plants for native insects and other wildlife.
- ✓ Reduce or eliminate localized or specialized native plant communities, such as spring ephemeral plant communities.
- ✓ Reduce the amount of space, water, sunlight and nutrients that would be available to native species.
- ✓ Reduce vigor of mature trees through shading.
- ✓ Replace nutritious native plant foods with lower quality sources.
- ✓ Serve as host reservoirs for plant pathogens and other organisms that can infect and damage desirable native and ornamental plants.

Barnyard Grass

Disturbance Effects

Invasive species are especially problematic in areas that have been disturbed by human activities such as road building, residential development, forest clearing, logging operations, grazing, mining, ditching of marshes for mosquito control, mowing, erosion control and fire prevention and control activities. Natural disturbances, such as fires, floods, tornadoes, landslides, and tree falls also provide avenues for invasive species to get started. The enormity of change wrought upon the American landscape over the past few hundred years has thrown things out of balance. Lacking exotic species, native species and ecosystems benefit from natural disturbances that provide opportunities for genetic mixing and nutrient recycling, and reduce fuel loadings.

Some native plants display invasive growth tendencies in their native ranges, often as a response to natural or human-caused disturbances. For example, native grape vines in forests may grow vigorously in response to a tree fall or selective timber cut that opens the canopy and brings abundant sunlight into previously shaded areas. This "invasive" growth spurt is usually temporary though, and slows down again as trees and other plants fill in and the forest canopy is recovered. The best way to reduce plant invasions is to focus on preventing non-native species introductions, managing existing infestations, minimizing disturbance to forests, wetlands, barrens and other natural communities.

Importance of Native Plants
Approximately 18,000 plants are native to the ecosystems of North America. Our native flora (i.e., all U.S. native plants) provides the foundation of the historic American landscape and defines the various ecosystems and regions of the country. These plants also provide natural sources of food and fiber, and were the essential sources of nutrition and other materials for native American Indians.

The populations of many native plants have been greatly reduced as a result of human encroachment which has destroyed many millions of acres of natural habitat. In the U.S. alone, about 200 native plant species have become extinct since the 1800's and 5,000 species are considered to be at risk. Invasions of non-native plants are the second greatest threat to native species after direct habitat destruction.

Musk Thistle

Broadleaves (dicots), Grasses (monocots), and Sedges

Weeds can be classified into three primary categories: broadleaves (dicots), grasses (monocots), and sedges. To identify broadleaf seedlings, it is common to look first at the cotyledons or seed leaves. The cotyledons are the first pair of leaves that open after emergence. Cotyledons have various shapes and sizes; they may be linear-, egg-, round- or butterfly-shaped or have variations of each. Look at other features of the weed, such as the true leaves (leaves emerging after cotyledons) and stems. Leaf shape can vary dramatically and is a consistent key to plant identification. The leaves may be alternately or oppositely arranged along the stem.

Some leaves may be attached to a short stem, known as the petiole, while others may lack a petiole. Check the leaf surfaces for the presence of hair and the amount of waxiness. Stems can also assist in identifying a weed; they have various shapes and amounts of hair, if any. Finally, dig or carefully remove the roots from the soil and look for the presence of rhizomes, creeping roots, or other structures such as tubers. Rhizomes are underground vegetative stems from which new plants are generated. The presence of these vegetative structures will indicate that the weed's life cycle is perennial.

Native Range

Every species of plant, animal, fungi, bacteria and other organism has a home in some part of the world, where it has existed for thousands of years as a result of natural forces and influences like climate, storms, moisture, fire, soils and species interactions. Over long periods of time, these and other physical and biological factors direct the distributions of organisms in nature. A native (indigenous) species is one that occurs in a particular region, ecosystem, and habitat without direct or indirect human actions (Kartesz and Morse, 1997). Species native to North America are generally recognized as those occurring on the continent prior to European settlement. Endemic is used to describe populations of native animals, plants or other organisms, that are have relatively restricted distributions and are confined to certain environments.

Organisms are considered non-native (alien, exotic, foreign, introduced, non-indigenous) when they occur artificially in locations beyond their known historical natural ranges. Non-native can refer to species brought in from other continents, regions, ecosystems and even other habitats. Species exotic to the U.S. include those transported from Europe, Asia, Africa, South America, Australia and other parts of the world. It also includes any species moved by people from one locality in the U.S. to a new one.

For example, black locust (Robinia pseudoacacia) is native to the southern Appalachian region of the eastern U.S. Because of its rapid growth and hardiness, it was planted all around the U.S. during this century for living fences, erosion control, wind breaks and other purposes. Even though it is native to the U.S., black locust is considered exotic anywhere it occurs outside its known historical natural range of southern Appalachia.

Once an Exotic, Always an Exotic! European settlers brought hundreds of plants to North America from their home lands, for food, medicinal, ornamental, and other purposes. Introductions of exotic plants continue today, and are increasing due to an exploding human population, increased international travel, and the intentional and accidental movement of large numbers of species between continents as a result of expanded international trade.

Many introduced plants have become naturalized across the continent and some are replacing North American native plant species. These naturalized plants, however much a part of our current landscapes and ecosystems, are nonetheless exotic, since they were moved here by people rather than by natural means. Because the historical distributions of some species are unknown or unclear, research continues to attempt to unravel the tangle of human and natural influences responsible for their current ranges.

Weed Classification Examples

Most common weeds fit into two large general classifications: broadleaves and grasses. Broadleaves and grasses may be further divided into annuals and perennials. Annual and perennial weeds may be even further subdivided by the seasons in which they germinate and grow.

(1) **Annuals**
Annual plants complete their life cycle in less than one year. Normally, they are considered easy to control. This is true for any one crop of weeds. However, because of an abundance of dormant seed and fast growth, annuals are very persistent. They actually cost more to control than perennial weeds. Most common field weeds are annuals. There are two types; summer and winter annuals.

(a) **Summer Annuals**
Summer annuals germinate in the spring, make most of their growth during the summer, and the plants mature and die in the fall. The seeds lie dormant in the soil until next spring.

(b) **Winter Annuals**
Winter annuals geminate in the fall and winter and usually mature seed in the spring or early summer before the plants die. The seeds often lie dormant in the soil during the summer months. In this group, high soil temperatures (125°F or above) have a tendency to cause seed dormancy. These are most troublesome in fall and early spring in ornamental plant areas.

(2) **Biennials**
A biennial plant lives for more than 1 year but not more than 2 years. Only a few troublesome weeds fall in this group. There is confusion between biennials and winter annuals, because the winter annual group normally lives during 2 calendar years and during 2 seasons.

(3) **Perennials**
Perennials live for more than 2 years and may live almost indefinitely. Most produce by seed and many are able to spread vegetatively. They are classified according to their method of reproduction as simple and creeping.

(a) **Simple Perennials**
Simple perennials spread by seed. They have no natural means of spreading vegetatively. However, if injured or cut, the cut pieces may produce new plants. For example a dandelion or dock root cut in half longitudinally may produce two plants. The roots are usually fleshy and may grow very large.

(b) **Creeping Perennials**
(1) Creeping perennials reproduce by creeping roots, creeping above ground stems (stolons), or creeping below-ground stems (rhizomes). In addition they may reproduce by seed.

(2) Some weeds maintain themselves and propagate by means of tubers, which are modified rhizomes adapted for food storage. Nutsedge (nutgrass) and Jerusalem artichoke are examples.

(3) Once a field is infested, creeping perennials are probably the most difficult group of weeds to control. Cultivators and plows often drag pieces about the field.

Continuous and repeated cultivations, repeated mowing for 1 or 2 years, or persistent herbicides are often necessary for control. Cultivation, in combination with herbicides, is proving effective on some creeping perennials. An effective eradication program also requires the killing of seedlings.

b. Types of Weeds

Note, there are thousands of weeds and variations, with that, we will not cover half the weeds, only the very common.

(1) **Broadleaf Weeds**

(a) **Annuals**

(1) **Summer Annuals** (Warm Season Annuals):

(a) Beggarticks
(b) Chickweed
(c) Wooly Croton
(d) Lambsquarters
(e) Redroot Pigweed
(f) Rough Pigweed
(g) Prostrate Pigweed
(h) Tumbling Pigweed
(i) Prickly Lettuce
(j) Annual Morning-glory
(k) Bedstraw
(l) Prostrate Spurge
(m) Spotted Spurge
(n) Puncture vine
(o) Purslane
(p) Common Ragweed
(q) Common Sunflower
(r) Annual Sow thistle

Prickly Lettuce

(2) **Winter Annuals:** (Cool Season Annuals): *Dicamba works well on most of these.*

(a) Bur Buttercup
(b) Pennycress
(c) Henbit
(d) Kochia
(e) Tansy Mustard
(f) Purple Mustard
(g) Fieldcress
(h) Flixweed
(i) Jim Hill Mustard
(j) Common Mustard
(k) Wild Mustard
(l) Larkspurs
(m) Wooly Locoweed
(n) Hoary Pea (Goatsrue)
(o) Mayweed
(p) Field Madder
(q) Russian Thistle
(r) Shepherd's Purse
(s) Tumble Mustard
(t) Yellow Rocket (Mustard)

Kochia

(b) **Biennials:**
(1) Bur Clover
(2) Burdock
(3) Cocklebur
(4) Chamomile
(5) Wild Carrot
(6) Spotted Knapweed
(7) Mullein
(8) Prickly Poppy
(9) Bull Thistle
(10) Musk Thistle
(11) Common Sow Thistle
(12) Yellow Star Thistle

(c) **Perennials**

(1) **Simple Perennials:**
(a) Jerusalem Artichoke

(b) Catnip
(c) Chickory
(d) Yellow Clover
(e) Dandelion
(f) Broadleaf Dock
(g) Curly Dock
(h) Narrow leaf Goldenrod
(i) Groundcherry
(j) Gumweed
(k) Broadleaf plantain
(l) Mallow (Cheeseweed)
(m) Milkweed
(n) Texas blueweed
(o) Prickly pear

(2) **Creeping Perennials:**
(a) Field Bindweed
(b) Wild Buckwheat
(c) Canada Thistle
(d) Russian Knapweed
(e) Mouse ear Chickweed
(f) Virginia Creeper

(2) **Grasses**

(a) **Annuals**
(1) **Summer Annuals:**
(a) Crabgrass
(b) Foxtails
(c) Barnyard grass
(d) Goose grass
(e) Sandbur
(f) Witchgrass
(g) Wild oats

Wild Carrot

Gumweed

Goosegrass

(2) **Winter Annuals:**
(a) Annual Bluegrass
(b) Foxtail Barley
(c) Fall Panicum
(d) Rescue grass
(e) Downy Brome
(f) Wild Rye

(b) **Perennial Grasses**

(1) **Simple Perennials:**
(a) Buffalo grass
(b) Rice Cutgrass
(c) Orchard Grass
(d) Gramma Grass
(e) Common Rush
(f) Perennial Ryegrass
(g) Reed Canarygrass

(2) **Creeping Perennials:**
(a) Bentgrass
(b) Bermuda Grass
(c) Dallisgrass
(d) Johnson grass
(e) Bluegrass
(f) Yellow Nutsedge
(g) Purple Nutsedge
(h) Quackgrass

Rescuegrass

Additional classifications may place weeds that occur in any of the above categories special categories. Weeds in special categories may require special practices to control them. Special categories have particular distinguishing features. Such distinguishing features may include special toxins dangerous to humans or livestock, woody stems, or aquatic habitats.

(1) **Toxic Plants:**
(a) African rue
(b) Woody Aster
(c) Foxglove
(d) Castor plant
(e) Poison Hemlock
(f) Hemp Dogbane
(g) Locoweed (Stemless, Wooly, etc.)
(h) Bitterweed
(i) Jimson Weed
(j) Silverleaf Nightshade
(k) Black Nightshade
(l) Groundcherry
(m) Perennial Broomweed
(n) Goldenrod
(o) Buffalo Bur

Jimson Weed

Toxic Plants Injurious to Humans
(1) Poison Ivy
(2) Poison Sumak
(3) Poison Oak

(4) Spurge (Bull) Nettle
(5) Stinging Nettle
(6) Slender Nettle

(2) **Woody plants and brush:**
(a) Elm Species
(b) Creosote
(c) Greasewood
(d) Coniferous trees & shrubs: Juniper, Cedars, Pine, Fir, and Spruce
(e) Maple Species
(f) Mesquite
(g) Oak Species
(h) Rose Species
(i) The Willow & Cottonwood Family

Stinging Nettle

(3) **Aquatic Plants** *See TLC's Aquatic Environment's Course*

(a) **Algae:**
(1) Single celled Algae
(2) Filamentous Algae
(3) Chara

Submerged Seed Plants
(1) Water Milfoil
(2) Hornwort
(3) Coontail
(4) Water Weed
(5) Pond Weed

Floating Weeds
(1) Water lilies (yellow & white)
(2) Water Hyacinth
(3)Duckweeds

Emergent Weeds
(1) Arrowhead
(2) Pipewort
(3) Cattails
(4) Bulrushes

Spurge (Bull) Nettle

Roundup-Resistant Weeds
Roundup-resistant weeds like horseweed and giant ragweed are forcing farmers to go back to more expensive techniques that they had long ago abandoned. There is a particularly tenacious species of glyphosate-resistant pest called Palmer amaranth, or pigweed, whose resistant form has begun to seriously infesting farms.

Pigweed can grow three inches a day and reach seven feet or more, choking out crops; it is so sturdy that it can damage harvesting equipment. In an attempt to kill the pest before it becomes that big, plow fields and mixing herbicides into the soil. That threatens to reverse one of the agricultural advances bolstered by the Roundup revolution: minimum-till farming. By combining Roundup and Roundup Ready crops, farmers did not have to plow under the weeds to control them. That reduced erosion, the runoff of chemicals into waterways and the use of fuel for tractors.

The term "weed" means different things to different people. In the broadest sense, it is any plant growing where it is not wanted. Weeds can be native or non-native, invasive or non-invasive, and noxious or not noxious. Legally, a noxious weed is any plant designated by a federal, state or county government as injurious to public health, agriculture, recreation, wildlife or property.

A noxious weed is also commonly defined as a plant that grows out of place (i.e. a rose can be a weed in a wheat field) and is "competitive, persistent, and pernicious."

The noxious weeds mandated for control are plants non-native to North America. Consequently, these plants do not have the natural checks as found in their native land, such as insects, diseases, and herbivores that would keep the plant population in check.

Due to the competitive aggressive ability of these plants coupled with no natural controls, these plants will develop mono-culture stands. Not only are many crops out competed by these weeds but native vegetation and the wildlife associated with it will be replaced.

Consequently, identifying the weeds when they first become established and developing an integrated weed management plan to control them is critical in maintaining healthy, productive land. The term noxious weed is used to describe a legal designation for plant species that have been determined to be especially undesirable or difficult to control.

Winter and Early Spring Broadleaf Plant Identification Key

I. Plants with spines
Spines on midveins - prickly lettuce
Short spines on stems - catchweed bedstraw
II. Plants with an ocrea
Twining growth habit - wild buckwheat
Plant forms dense mats - prostrate knotweed
Plant forms a rosette
>Leaves have wavy margin - curly dock
>Leaves are wide and lobed at base - broadleaf dock
III. Plants with square stems
Shorts spines on stems - catchweed bedstraw
Stems without spines, pink to purple flowers, upright growth habit - henbit or purple deadnettle
Stems without spines, pink to purple flowers, sprawling growth habit forming dense mats - ground ivy
IV. Plants with milky sap
Spines on midvein - prickly lettuce
No spines - dandelion, western salsify or venuslookingglass
V. Plants with finely dissected leaves
Fernlike appearance - tansy mustard
Sweet aroma - pineapple weed
VI. Plants covered with hair
Long, loose, white hair - cornflower
Hairy, reddish, highly branched stems - cutleaf evening primrose
Hairy, notched leaves opposite on upper parts of plant - corn speedwell
More of less hairy with erect growth habit - horseweed or corn gromwell
VII. Dense, short, fuzzy hair
>Young seedling plants form a basal rosette - kochia
>Large gray-green leaves form a rosette, flannel-like feel - common mullein
>Small leaves, plant forms a mat - mouseear chickweed
>Leaves clasp around the stem - daisy fleabane
VIII. Plants form dense mats
Plant has an ocrea - prostrate knotweed
Plant without an ocrea
>Small, opposite pubescent leaves - mouseear chickweed
>Small, opposite smooth leaves; upper leaves lack petioles - common chickweed
>Hairy, notched leaves opposite on upper parts of plant - corn speedwell
>Alternate leaves lack petioles; hairy on both surfaces - corn gromwell
X. Plants with a basal rosette
Leaves deeply cut or toothed - buttercups, Carolina geranium, dandelion, prickly lettuce, shepherd's-purse, small flowered bittercress, tansy mustard, Virginia pepperweed, wild mustard or pineapple weed
Leaves irregularly cut or toothed - daisy fleabane, purslane speedwell, shepherd's-purse, wild mustard, curly dock, broadleaf dock, cutleaf evening primrose, butterweed or field pansy
Leaves not cut - kochia, common mullein, broadleaf plantains, buckhorn plantain or venuslookingglass
Leaves may or may not be cut - bushy wallflower, field pennycress or yellow rocket

Summer Broadleaf Plant Identification Key

I. Cotyledons lanceolate or linear
First true leaves alternate
Ocrea present where petiole joins stem
>>Leaves heart-shaped - wild buckwheat
>>Leaves not heart-shaped - Pennsylvania smartweed, pale smartweed, ladysthumb smartweed, swamp smartweed, prostrate knotweed or Japanese knotweed
No ocrea present
>>Linear cotyledons with prominent midvein, foul odor when crushed - jimsonweed
>>No foul odor, first leaves have notch in tips
>>>Leaves and stems lack hair, erect growth habit
>>>>Plant has stiff spines - spiny amaranth
>>>>Plant lacks spines - common waterhemp or Palmer amaranth
>>>Leaves and stems lack hair, prostrate growth habit - prostrate pigweed
>>>Upper stems hairy, erect growth habit, flower spikes compact and thick - redroot pigweed
>>>Stems and leaves with sharp spines - buffalobur
First true leaves opposite, subsequent leaves alternate
Cotyledons are thick and fleshy, hypocotyls are reddish in color and leaves have coarse texture with 3 prominent veins - common cocklebur
Cotyledons are small and linear
>>Stems and leaves lack hair; leaves appear "frosted" - common lambsquarters
>>Stems and leaves lack hair; leaves thick and succulent, some opposite – common purslane

II. Cotyledons ovate
Leaf surfaces hairy
>Leaf hairs very sticky - hairy nightshade
>Leaf hairs not sticky, stems very hairy -
>>Compact growth habit - clammy groundcherry
>>Erect, columnar growth habit - horseweed
Leaf surfaces nearly lacking or lacking hair
>Plant rhizomatous perennial - smooth groundcherry
>Plant annual - black nightshade

III. Cotyledons round to heart-shaped
Heart-shaped leaves covered with dense, fuzzy pubescence, margins entire - velvetleaf
Leaves with hair on both surfaces, irregularly lobed, purple veins - spurred anoda
Leaves with 3 - 7 coarsely toothed lobes, smooth on upper surface, hairy on lower surface - Venice mallow
Leaves are finely serrated along margins
>Fleshy spine projections in leaf axils, leaves - prickly sida
>Leaves ovate in shape with heart-shaped base and terminal tips - hophornbeam copperleaf
Leaves lack hair, compound with 4 - 6 leaflets - sicklepod
Leaves are rounded and have toothed margins - common mallow
First leaves are opposite, subsequent leaves alternate with sparse hair - Virginia copperleaf

IV. Cotyledons spatulate or oval
First leaves alternate
>Compound leaves with many small leaflets - hemp sesbania
>Large 5-sided leaves with 3 primary lobes, vining growth habit - burcucumber
>Whorled leaves; plant roots at nodes - carpetweed

First leaves opposite, later leaves may be alternate

>Small cotyledons, leaves finely divided - common ragweed
>Large cotyledons, first leaves simple, subsequent leaves have 3 major lobes - giant ragweed
>Leaves glandular hairy with foul odor - unicorn plant
>Stems have milky sap - prostrate spurge, nodding spurge or toothed spurge
>Leaf surfaces rough textured with 3 prominent veins
>>Plant annual - common sunflower
>>Plant perennial from underground tubers, petioles are winged - Jerusalem artichoke

First and subsequent leaves opposite

>Leaf margins with irregular teeth, lack petioles, succulent reddish-brown stems - eclipta

V. Cotyledons butterfly-shaped

Cotyledons with pointed tips cut at approximately 90 degrees - pitted morningglory
Cotyledons with rounded tips cut less than 90 degrees
>Ivy-shaped leaves - ivyleaf morningglory
>Heart-shaped leaves
>>Plant annual - tall morningglory
>>Plant perennial from tuberous root - bigroot morningglory

VI. Cotyledons kidney-shaped

Leaves hairy with wavy, uneven margins - wild mustard
Leaves arrowhead-shaped, plant perennial, vining habit
>Leaf bases have sharp lobes that point outward - hedge bindweed
>Leaf bases have rounded lobes - field bindweed

Wild Mustard

Prickly Pear Cactus

Prickly pear cactus represents about a dozen species of the **Opuntia** genus (**Family Cactaceae**) in the North American deserts. All have flat, fleshy **pads** that look like large leaves. The pads are actually modified branches or stems that serve several functions -- water storage, photosynthesis and flower production. **Chollas** are also members of the Opuntia genus but have cylindrical, **jointed stems** rather than flat pads.

Like other cactus, most prickly pears and chollas have large spines -- actually modified leaves -- growing from **tubercles** -- small, wart-like projections -- on their stems. But members of the Opuntia genus are unique because of their clusters of fine, tiny, barbed spines called **glochids**. Found just above the cluster of regular spines, glochids are yellow or red in color and detach easily from the pads. Glochids are often difficult to see and more difficult to remove, once lodged in the skin.

Prickly pear cactus are found in all of the deserts of the American Southwest, with different species having adapted to different locale and elevation ranges. Most require coarse, well-drained soil in dry, rocky flats or slopes. But some prefer mountain pinion/juniper forests, while others require steep, rocky slopes in mountain foothills.

Description
Most prickly pear cactus have yellow, red or purple flowers, even among the same species. They vary in height from less than a foot (Plains, Hedgehog, Tuberous) to 6 or 7 feet (Texas, Santa Rita, Pancake). Pads can vary in width, length, shape and color. The Beavertail, Santa Rita and Blind Pear are regarded as spineless, but all have glochids.

In addition to the North American native prickly pear cactus, there are many varieties, non-native imports and hybrids, so identification can often be difficult.

Common Weeds of Field Crops and Pastures

Common Name	Scientific Name
Barley, little	*Hordeum pusillium*
Barnyardgrass	*Echinochloa crus-galli*
Bermudagrass	*Cynodon dactylon*
Bluegrass, annual	*Poa annua*
Broadleaf signalgrass	*Brachiaria platyphylla*
Brome, downy	*Bromus tectorum*
Cheat	*Bromus secalinus*
Crabgrass, large	*Digitaria sanguinalis*
Crabgrass, smooth	*Digitaria ischaemum*
Dallisgrass	*Paspalum spp.*
Dayflower	*Commelina spp.*
Fall panicum	*Panicum dichotomiflorum*
Field horsetail	*Equisetum spp.*
Foxtail barley	*Hordeum jubatum*
Foxtail, Carolina	*Alopecurus carolinianus*
Foxtail, giant	*Setaria faberi*
Foxtail, green	*Setaria viridis*
Foxtail, yellow	*Setaria glauca*
Goosegrass	*Eleusine indica*
Johnsongrass	*Sorghum halepense*
Orchardgrass	*Dactylis glomerata*
Quackgrass	*Elytrigia repens*
Rush	*Juncus spp.*
Ryegrass, perennial	*Lolium perenne*
Sandbur	*Cenchrus longispinus*
Shattercane	*Sorghum bicolor*
Star-of-Bethlehem	*Ornithogalum umbellatum*
Wild garlic	*Allium vineale*
Wild onion	*Allium canadense*
Witchgrass	*Panicum capillare*

Woolly cupgrass	*Eriochloa villosa*

Common Grasses and their Scientific Names

Common Name	**Scientific Name**
Annual bluegrass	*Poa annua*
Barnyard grass	*Echinochloa crus-galli*
Bermuda grass	*Cynodon dactylon*
Crabgrass, large	*Digitaria sanguinalis*
Crabgrass, smooth	*Digitaria ischaemum*
Dallis grass	*Paspalum spp.*
Dayflower	*Commelina spp.*
Foxtail, giant	*Setaria faberi*
Foxtail, green	*Setaria viridis*
Foxtail, yellow	*Setaria glauca*
Goosegrass	*Eleusine indica*
Nimblewill	*Muhlenbergia schreberi*
Ryegrass, perennial	*Lolium perenne*
Quackgrass	*Elytrigia repens*
Sandbur	*Cenchrus longispinus*
Star-of-Bethlehem	*Ornithogallum umbellatum*
Wild garlic	*Allium vineale*
Wild onion	*Allium canadense*
Yellow nutsedge	*Cyperus esculentus*

Star-of-Bethlehem *Ornithogallum umbellatum*

Grass and Grass-like Plant Identification Key

Leaves arise from bulb - wild onion, wild garlic or Star-of-Bethlehem
Stems triangular - yellow nutsedge
Leaves form sheath at stem, blue-purple flowers - dayflower
Ligule absent - barnyardgrass
Ligule membranous

Blade or sheath with dense hairs
>First leaf wide and short, decumbent growth habit - large crabgrass
>Leaf blades distinctly twisted, winter annual - downy brome

Blade and sheath hairless or sparsely hairy
>Blades wide, short
>>Sparse hairs near collar, decumbent growth habit - smooth crabgrass
>>Prominent veins, sheath flat with whitish base - goosegrass
>Blades narrow and erect
>>Auricles present, smooth white rhizomes - quackgrass
>>Auricles absent
>>>Winter annual, forms clumps, blade tips prow-shaped - annual bluegrass
>>>Perennial with rhizomes, seed oblong-shaped - Johnson grass
>>>Summer annual, resembles Johnson grass but has no rhizomes, large shiny black ovate seed - shattercane

Ligule hairy Blade with hair
>Short hair on upper surface - giant foxtail
>Long hair on upper leaf surface near base of blade - yellow foxtail
>Blades and sheath covered with dense short hair, sheath hair at 90 degree angle to stem -witchgrass
>Very short dense hair on blades, first leaf horizontal, blade margin often crimped, large seed - woolly cupgrass

Blade with little or no hair
>Sheath margin hairy - green foxtail

Sheath margin usually hairless or with a few hairs
>>Perennial, rhizomes and stolons present, roots at nodes, decumbent growth habit - bermudagrass
>>Sheath round, hair on underside of first leaf, later leaves smooth, prominent white midvein - fall panicum
>>Sheath flattened, usually reddish in color, large spiny seed - field sandbur

Coneflower

Buckwheat

Jimsonweed *Datura stramonium*

Common Broadleaf Plants *with some suggested remedies and classification.*

Arrowhead	*Sagittaria montevidensis*
Balloonvine	*Cardiospermum halicacabum Annual can be Perennial in some areas*
Beggarweed	*Desmodium spp. Perennial*
Bindweed, field **(noxious)**	*Convolvulus arvensis Perennial*
Bindweed, hedge	*Convolvulus sepium Perennial*
Bittercress, smallflowered	*Cardamine parviflora*
Black nightshade	*Solanum spp. Halosulfuron, Rimsulfuron Annual*
Broadleaf plantains	*Plantago spp. 2,4D, 2,4DP, Cloryralid, Dicamba, MCPA, Triclopyr*
Buckhorn plantain	*Plantago lanceolata Perennial*
Buffalobur	*Solanum rostratum Perennial*
Bull thistle	*Cirsium vulgare Biennial 2-4D*
Burcucumber	*Sicyos angulatus Annual Beacon , Banvel, Clarity or Marksman*
Bushy wallflower	*Erysimum repandum Annual Maverick*
Buttercups	*Ranunculus spp. Perennial*
Butterweed	*Senecio glabellus Annual*
Canada thistle	*Cirsium arvense*
Carolina geranium	*Geranium carolinianum*
Carpetweed	*Mollugo verticillata Annual*
Chicory	*Cichorium intybus Perennial*
Clammy groundcherry	*Physalis heterophylla Annual*
Common burdock	*Arctium minus Annual*
Common chickweed	*Stellaria media Annual*
Common cocklebur	*Xanthium strumarium Annual*
Common groundsel	*Senecio vulgaris Annual*
Common lambsquarters	*Chenopodium album Annual*
Common milkweed	*Asclepias syriaca Perennial Amitrol, Roundup Tordon*
Common mullein	*Verbascum thapsus Perennial Roundup, Garlon, Triclophr*
Common pokeweed	*Phytolacca Americana Perennial Glyphosate for control*
Common purslane	*Portulaca oleracea Annual 2,4D, MCPP and banvel (Dicamba)*
Common ragweed	*Ambrosia artemisiifolia Annual Tenran*
Common sunflower	*Helianthus annuus Annual Clopyralid for control*
Common teasel	*Dipsacus fullonum Perennial 2,4D, MCPP and Banvel or Dicamba*
Common waterhemp	*Amaranthus rudis Annual Sahara (Imazapyr and Diuron)*
Common yarrow	*Achillea millefolium P 2,4D, 2,4DP, Clopyralid MCPP Banvel Dicamba*
Compass plant	*Silphium laciniatum Perennial*
Corn gromwell	*Lithospermum arvense Annual*
Cornflower	*Centaurea cyanus Annual Picloram*
Croton, tropic	*Croton glandulosus*
Croton, woolly	*Croton capitatus*
Cup plant	*Silphium perfoliatum Perennial Glyhospate*

Curly dock	*Rumex crispus Perennial 2,4D, MCPP and Banvel or Dicamba*
Cut-leaf teasel **(noxious)**	*Dipsacus laciniatus B 2,4D, 2,4DP, MCPP and Banvel or Dicamba*
Cutleaf eveningprimose	*Oenothera laciniata A & P Oxyfluorfen, 2,4D +Paraquat*
Daisy fleabane	*Erigeron annuus Annual Sahara (Imazapyr and Diuron)*
Deadnettle, purple	*Lamium purpureum*
Dewberry	*Rubus spp. Perennial*
Eclipta	*Eclipta prostrate Annual and Perennial*
Field dodder	*Cuscuta campestris Perennial*
Field pansy	*Viola rafinesquii Annual*
Giant ragweed	*Ambrosia trifida Annual*
Goldenrod	*Solidago spp. Annual and Perennial*
Greenbriar	*Smilax spp. Perennial*
Hairy nightshade	*Solanum sarrachoides*
Hemp dogbane	*Apocynum cannabinum*
Hemp sesbania	*Sesbania exaltata*
Henbit	*Lamium amplexicaule*
Honeysuckle	*Lonicera spp. Perennial Sahara (Imazapyr and Diuron)*
Honeyvine milkweed	*Cynanchum leave Perennial Garlon 4 (Triclopyr)*
Hophornbeam copperleaf	*Acalypha ostryaefolia Annual Roundup*
Horsenettle	*Solanum carolinense A & Biennial Sahara (Imazapyr and Diuron)*
Horseweed	*Erigeron canadensis*
Illinois bundleflower	*Desmanthus illinoensis Perennial Roundup*
Ironweed	*Vernonia spp. Perennial Saber- Sahara (Imazapyr and Diuron)*
Japanese hedgeparsley	*Torilis arvensis Annual Roundup*
Japanese hops	*Humulus japonicus Annual Perennial Glyphospate*
Japanese knotweed	*Polygonum cuspidatum P Cut Stump treatment Glyphosate- Triclopyr*
Jerusalem artichoke	*Helianthus tuberosus*
Jimsonweed	*Datura stramonium Annual Perennial Bentazon for control*
Kochia	*Kochia scoparia Annual Dicamba*
Kudzu **(noxious)**	*Pueraria lobata Perennial Glyhospate*
Marijuana **(noxious)**	*Cannabis sativa*
Morning-glory, bigroot	*Ipomoea pandurata Perennial Sahara Imazapyr and Diuron*
Morning-glory, ivyleaf	*Ipomoea hederacea Annual Sahara Imazapyr and Diuron*
Morning-glory, tall	*Ipomoea purpurea Annual Sahara Imazapyr and Diuron*
Morning-glory, pitted	*Ipomoea lacunose Annual Sahara Imazapyr and Diuron*
Mouse ear chickweed	*Cerastium vulgatum Annual Dicamba*
Mousetail	*Myosurus minimus Annual 2-4D*
Multiflora rose **(noxious)**	*Rosa multiflora Perennial Dicamba*
Musk thistle **(noxious)**	*Carduus nutans*
Nodding spurge	*Euphorbia nutans Annual 2-4D Diphenylether*
Oxeye daisy	*Chrysanthemum leucanthemum P Sahara Imazapyr and Diuron*

Palmer amaranth	*Amaranthus palmeri Annual Sahara*
Partridgepea	*Cassia chamaecrista Annual 2-4D*
Pennycress, field	*Thlaspi arvense Annual 2-4D, Sahara*
Perilla mint	*Perilla frutescens Annual 2-4D, Sahara*
Pigweed, prostrate	*Amaranthus blitoides Annual Sahara (Imazapyr and Diuron)*
Pigweed, redroot	*Amaranthus retroflexus Annual Sahara (Imazapyr and Diuron)*
Pigweed, tumble	*Amaranthus albus Annual Sahara (Imazapyr and Diuron)*
Pineapple weed	*Matricaria matricarioides Annual Sahara (Imazapyr and Diuron)*
Poison hemlock	*Conium maculatum Biennial Tebuthiuron (Spike 20P) Glean FC, Velpar*
Prickly lettuce	*Lactuca serriola Annual STOMP*
Prickly pear	*Opuntia compressa Perennial Tordon 22K Picloram*
Prickly sida	*Sida spinosa Annual/Perennial Sahara (Imazapyr and Diuron)*
Prostrate knotweed	*Polygonum aviculare*
Puncturevine	*Tribulus terrestris Annual Sahara (Imazapyr and Diuron)*
Purple ammannia	*Ammannia coccinea*
Purple loosestrife **(noxious)**	*Lythrum salicaria Pernnial Roundup or Rodeo*
Purslane speedwell	*Veronica peregrina*
Rattlesnake master	*Eryngium yuccifolium*
Redvine	*Brunnichia ovata*
Rosinweed	*Silphium integrifolium*
Scotch thistle **(noxious)**	*Onopordum acanthium A or B Piclram, dicamba + 2,4-D, Metsulfuron*
Sericea lespedeza	*Lespedeza cuneata Perennial Triclohr*
Shepherd's purse	*Capsella bursa-pastoris A 2,4-D, 2,4DP;chlorsulfuron, dicamba, MCPA*
Sicklepod	*Senna obtusifolia*
Smartweed, ladysthumb	*Polygonum persicaria*
Smartweed, pale	*Polygonum lapathifolium*
Smartweed, Pennsylvania	*Polygonum pensylvanicum*
Smartweed, swamp	*Polygonum coccineum Perennial 2-4D Dicamba Rodeo*
Smooth groundcherry	*Physalis subglabrata*
Smooth sumac	*Rhus glabra*
Snow-on-the-mountain	*Euphorbia marginata*
Spanish needles	*Bidens bipinnata*
Spiny amaranth	*Amaranthus spinosus*
Spiny sowthistle	*Sonchus asper*
Spurge, leafy	*Euphorbia esula*
Spurge, nodding	*Euphorbia nutans*
Spurge, prostrate	*Euphorbia humistrata*
Spurge, toothed	*Euphorbia dentata*
Spurred anoda	*Anoda cristata*
Tall thistle	*Cirsium altissimum*
Tansy mustard	*Descurainia pinnata*

Trumpetcreeper	*Campsis radicans*
Unicorn-plant	*Proboscidea louisianica*
Velvetleaf	*Abutilon theophrasti*
Venice mallow	*Hibiscus trionum*
Venuslookingglass	*Triodanis perfoliata*
Vervain, blue	*Verbena hastata*
Vervain, hoary	*Verbena stricta*
Vetch	*Vicia spp.*
Virginia copperleaf	*Acalypha virginica*
Virginia creeper	*Parthenocissus quinquefolia*
Virginia pepperweed	*Lepidium virginicum*
Water hemlock	*Cicuta maculata*
Western salsify	*Tragopogon dubuis*
White heath aster	*Aster pilosus*
White snakeroot	*Eupatorium rugosum*
Wild buckwheat	*Polygonum convolvulus*
Wild carrot	*Daucus carota*
Wild indigo	*Baptisia spp.*
Wild lettuce	*Lactuca serriola*
Wild mustard	*Brassica kaber*
Yellow rocket	*Barbarea vulgaris*

Author's Note: There are several weed databases that you can utilize for weed identification. Here are a couple of great websites; plants.usda.gov/weedsofcalifornia and psu.missouri.edu.

I would like to mention that scientific names of weeds and plants do change over time. If there is any doubt on your assignment, utilize the federally listed name or the name that is used in this manual.

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Johnson grass, *Sorghum halapense* (L.) Pers. - non-native

A monocot in the Poaceae family. It is said to have been brought here in the early 1900's from Europe as a feed grain for stock. It was grown in great quantities until it was determined it had very little nutritional value. By then it had naturalized and was out of control. It can grow to the height of 7-8 feet. It propagates itself by heavy seeding and by underground rhizomes (thick root sections like iris bulbs).

Commonly Found Weeds
(Short Summarymore detailed information in next topics)

Field Bindweed *Convolvulus arvensis*

Russian Knapweed *Acroptilon repens*

Note, there are thousands of weeds and variations, with that, we will not cover half the weeds, only the very common.

Field bindweed can be spread by seed, root fragments, farm implements, infested soil adhering to the roots of nursery stock, root growth from infested areas, and by animals. Field bindweed has a deep root system that competes with crop plants for water and nutrients. Vines climb on plants and shade crops, cause lodging of small grains, and make harvesting difficult by clogging machinery. Dense field bindweed infestations may reduce crop yields by 50 to 60 percent. Land infested with field bindweed is reduced in value.

Field bindweed is a long-lived perennial which produces a dense ground cover. The twining stems vary from 1.5 to 6 feet or more in length. Leaf size and shape are variable, but generally the leaves are 1 to 2 inches long, smooth, and shaped like an arrowhead. Flowers are funnel-shaped, about 1 inch diameter, and white or pink in color. The flower stalk has two small bracts located ½ to 2 inches below the flower. The bracts, along with leaf shape and smaller flower size, distinguish field bindweed from hedge bindweed.

Russian knapweed (*Acroptilon repens*) is a creeping, herbaceous perennial of foreign origin that reproduces from seed and vegetative root buds. Shoots or stems, are erect, 18 to 36 inches tall, with many branches. Lower leaves are 2 to 4 inches long and deeply lobed. Upper leaves are smaller, generally with smooth margins, but can be slightly lobed.

Shoots and leaves are covered with dense gray hairs. The solitary, urn-shaped flower heads occur on shoot tips and generally are 1/4 to 1/2 inch in diameter with smooth papery bracts.

Flowers can be pink, lavender or white. Russian knapweed has vertical and horizontal roots that have a brown to black, scaly appearance, especially apparent near the crown.

Russian knapweed emerges in early spring, bolts in May to June, and flowers through the summer into fall. Russian knapweed is toxic to horses. The key to Russian knapweed control is to stress the weed and cause it to expend nutrient stores in its root system. The best management plan includes cultural controls combined with mechanical and/or chemical control techniques.

Scotch thistle *Onopordum acanthium*

Canada thistle *Cirsium arvense*

Scotch thistle is a branched, robust biennial (or sometimes annual) that often grows 8 feet or more in height and 6 feet in width. Main stems may be up to 4 inches wide at the base. Stems have vertical rows of prominent, spiny, ribbon-like leaf material or "wings" that extend to the base of the flower heads. Leaves, which are armed with sharp, yellow spines, are up to 2 feet long and 1 foot wide. Upper and lower leaf surfaces are covered with a thick mat of cotton-like or woolly hairs, which give the foliage a gray-green appearance. Plants flower in mid-summer. The globe-shaped flower heads are borne in groups of 2 or 3 on branch tips. Flower heads are up to 2 inches in diameter, with long, stiff, needle-like bracts at the base. Flowers range from dark pink to lavender. Seeds are smooth, slender, and plumed.

Canada thistle (*Cirsium arvense*) is an aggressive, creeping perennial weed that infests crops, pastures, rangeland, roadsides and non-crop areas. Generally, infestations start on disturbed ground, including ditch banks, overgrazed pastures, tilled fields or abandoned sites. Canada thistle reduces forage consumption in pastures and rangeland because cattle typically will not graze near infestations. Canada thistle is a creeping perennial that reproduces from vegetative buds in its root system and from seed. It is difficult to control because its extensive root system allows it to recover from control attempts. Combining control methods is the best form of Canada thistle management. Persistence is imperative so the weed is continually stressed, forcing it to exhaust root nutrient stores and eventually die.

Dalmatian toadflax *Linaria dalmatica*

Diffuse knapweed *Centaurea diffusa*

Toadflax is a menace throughout the northwest and infestations range from light to heavy, with some densities ranging up to 100% of the existing vegetation. This may be explained through the plant's ability to inhibit other plant species from becoming established - this is known as an "El Nino" effect or allelopathic condition. Dalmatian very much resembles its sister species yellow toadflax (*Linaria vulgaris*); however, the Dalmatian species has wider leaves which clasp the stem.

Dalmatian toadflax, a native of the Mediterranean region, was introduced to the Americas in 1900 as an ornamental. The pioneers loved this plant because of its lavish, bright yellow flowers and its durability. Toadflax was easy to establish and homesteaders liberally landscaped their properties with this drought resistant plant, continually spreading it in their migration to the Western frontier. Also, burial sites were often adorned with toadflax to give everlasting beauty and tranquility. Their legacy has prevailed, proving to be notorious in nature.

Diffuse knapweed is a member of the Aster family, Thistle tribe. Diffuse knapweed was introduced from Europe and is a biennial or short-lived perennial forb which reproduces only by seed. The plant usually produces a single main, much-branched stem that is 1-1/2 to 2 feet tall. It is known to have more than one stem produced from one rosette. A basal rosette of leaves is present in young plants with each leaf divided into narrow segments. When leaves are young, a thin nap is present. Stem leaves in the mature plant become much reduced as you ascend to the tip and alternate one per node. Flowers are mostly white, sometimes purple, and are located on each branch tip. The bracts surrounding each flower bear 4 to 5 pairs of lateral spines and one, long terminal spine. Diffuse knapweed can resemble spotted knapweed with the black tipped bracts. The difference is the sharp spine at the end of the bract that is characteristic of diffuse knapweed.

Leafy spurge *Euphorbia esula*

Musk thistle *Carduus nutans*

Leafy spurge (*Euphorbia esula L.*) is a creeping, herbaceous perennial weed of foreign origin that reproduces from seed and vegetative root buds. It can reduce rangeland cattle carrying capacity by 50 to 75 percent. About half of this loss is from decreased grass production. Cattle won't graze in dense leafy spurge stands and these areas are a 100% loss to producers. Leafy spurge is difficult to control. Its extensive root system has vast nutrient stores that let it recover from control attempts. Combine control methods into a system to achieve best results.

Musk thistle is an aggressive weed of foreign origin that occurs in pastures, rangeland, roadsides and non-crop areas. It is a biennial weed, although occasionally it is an annual. Because musk thistle reproduces solely from seed, the key for successful management is to prevent seed production. Musk thistle is a biennial weed that reproduces only from seed.

The key to successful musk thistle control is to prevent seed production. Apply herbicides such as Tordon, Vanquish/Clarity or 2,4-D to musk thistle rosettes in spring or fall. Apply Ally or Telar up to the early flower growth stage. Combine control methods into a management system for best results. Germination and seedling establishment are correlated with moisture and light. Thus, more seeds germinate and establish plants in open pastures and other degraded areas.

Vigorously growing grass competes with musk thistle, and fewer thistles occur in pastures where grazing is deferred. However, musk thistle also can become a problem in pasture or rangeland that is in good condition.

Foxtail *Setaria glauca*

Black medic *Medicago lupulina*

Foxtail is a summer annual grass with wider blades and a lighter green color than bluegrass. It is also faster growing than bluegrass. Seed heads may form despite regular mowing. Foxtail is much less prevalent when turfgrass has good density. Re-sod or reseed bare spots.

Control A pre-emergent herbicide (benefin + trifluralin, dithiopyr, oxadiazon, pendimethalin or prodiamine) applied correctly and at the proper time should provide control. Do not use a pre-emergent herbicide on a newly-seeded or sodded lawn or when overseeding a lawn. Post-emergent herbicides that will kill foxtail seedlings: MSMA, DSMA, MAMA or fenoxaprop.

Black medic is an annual, biennial or short-lived perennial. A legume, it is closely related to alfalfa. It is most often found in lawns having low fertility. Often called Japanese clover, this plant has small yellow flowers and a deep taproot. It can be pulled from moist soil without difficulty. Keeping your lawn healthy and dense with proper watering, mowing, and fertilization will discourage invasion by black medic.

Control Triclopyr + 2,4-D combination herbicides or other 2,4-D combination herbicides are more effective than 2,4-D alone.

Yellow Alyssum is a member of the mustard family. An exotic imported from Europe, it threatens native grasses. The plants grow from 4 to 8 inches in height and branch at the base. The leaves are narrow, strap-like, and covered with star-shaped hairs. In spring, yellow flowers are borne in racemes. Seeds are formed in silicles that are round, flattened, and pointed at the top, much like a bellows. In summer, seeds drop out of the center of the pods, leaving a skeleton that resembles a pair of "spectacles."

Control Yellow alyssum has a taproot that can be easily hand-pulled from moist soil in the garden. Post-emergent treatment with 2-4,D, or triclopyr is effective in controlling this weed in turfgrass. Yellow alyssum can be spot treated with glyphosate (Round-up, Kleen-up).

Yellow Alyssum *Alyssum alyssoides* **Shepherd's Purse** *Capsella bursa-pastoris*

Shepherd's Purse Another member of the mustard family, Shepherd's purse can produce over 33,000 seeds per plant. The lower leaves are petioled and deeply lobed, quite similar to that of a dandelion. The upper leaves are irregularly toothed and clasping. White flowers appear in clusters at the top of a flower stalk that can reach 6 to 18 inches in height. The flowers are only about 2mm across. Seeds are contained in silicles that are notched triangles and resemble the purses once carried by shepherds.

Control Shepherd's purse has a slender taproot and can be easily hand-pulled or hoed from moist soil in flower and vegetable gardens while plants are young. In lawns, post-emergent herbicides provide easier control of Shepherd's purse than pre-emergents. Spot treat by spraying individual plants, rather than applying a weed and feed over the entire lawn. If you would rather not spray, the herbicide can be brushed on instead. Apply the herbicide in mid-spring and again in mid-autumn if a new crop of shepherd's purse emerges. These herbicides are most effective when temperatures are between 60-80°F. Do not spray if temperatures are projected to exceed 85°F within the next 48 hours. Choose a time when no rain is forecast for at least 24, and preferably, 48 hours. To avoid herbicide drift, spray only when the air is still. Drift can harm or kill desirable broadleaf plants such as flowers, vegetables, trees and shrubs. Post-emergent herbicides should be labeled for use in turfgrass and contain a combination of 2,4-D and MCPP or 2,4-D, MCPP and dicamba. Do not apply any product containing dicamba underneath the canopy of young trees, near shrubs or close to gardens, as it can be absorbed by their roots.

Blue Mustard *Chorispora tenella* **Henbit** *Lamium amplexicaule*

Blue mustard is a winter annual that germinates in the fall and produces a rosette with deeply lobed leaves, similar in appearance to a dandelion. Blue mustard bears purple or blue flowers at the top of the plant in March through April. Leaves on the flowering stems are coarsely toothed and have wavy margins. The plant may grow from 1 to 1 1/2 feet in height. Two-inch long, bean-like seedpods (siliques) that resemble "beaks" mature in early summer.
Control Herbicides are most effective if applied before weeds start to bolt in the spring. In the spring, while it is actively growing, this weed can be controlled with an application of 2,4-D.

Henbit is a winter annual occasionally found in lawns in early spring. The lower leaves have a stalk while the upper leaves clasp the stem. Stems are square, like other members of the mint family. All the leaves are coarsely toothed and opposite from each other. Flowers appear in May and are about one-half inch long, trumpet-shaped, pinkish white to purple, and form just above upper leaves. This weed is more often found in buffalograss than in bluegrass. Newly-seeded bluegrass and established bluegrass lawns with poor density may have some henbit.
Control Henbit has a taproot and is easily pulled from moist soil. Heavy infestations can be controlled with triclopyr + clopyralid, 2,4-D or 2,4-D combination herbicides; at or prior to flowering. Fall application of a pre-emergent herbicide (dithiopyr, isoxaben, pendimethalin or prodiamine) will prevent henbit germination.

White Clover is a perennial that forms creeping runners. These runners will root at nodes. Many people like clover in lawns, while others find white flowers and the bees they attract objectionable. Clover is a legume which fixes nitrogen, so it is often found in lawns having low fertility. To discourage it, increase turf density with proper watering, mowing and fertilization.
Control Triclopyr + 2,4-D combination herbicides or other 2,4-D combination herbicides can be used. 2,4-D alone is not effective.

Buffalo bur, sometimes called Kansas thistle and prickly nightshade, is a tap rooted annual weed. It bears long, yellow spines on stems, leaves, and flower heads and can grow up to 2 feet high. Drought resistant, its highest occurrence is in dry, exposed soil. The oblong leaves are 2-3 inches long with deep rounded lobes and are covered with very dense, stiff, and sharp spines. Bright yellow flowers can be seen in summer. In the fall, berries up to 3/8 inch in diameter are enclosed in the dried flower parts and are filled with black, wrinkled, flat pitted seeds. Control of this plant is important, as it is a host for the Colorado potato beetle. When mature, the main stem breaks near the ground and the plant rolls like a tumbleweed, widely scattering the 8500 seeds that each plant produces. Buffalo bur can be pulled when the soil is moist. Be sure to wear gloves to avoid injury from the spines.
Control Herbicides should be applied between late bud to early flower. Dicamba, Triclopyr and 2,4-D can be effective in controlling Buffalo bur. Glyphosate in a 2% solution can be applied as a spot treatment.

Puncture vine is a prostrate, mat-forming summer annual. It has small leaflets and small yellow flowers with 5 petals. Fruits containing seeds are a sharp, spiny burr that can easily puncture a bicycle inner tube (or gardener's skin!). This weed is found only in thin, less vigorous turf given insufficient water. It will pull easily out of moist soils. Be sure to wear gloves to protect your hands from the burrs. You can discourage the growth of puncture vine by increasing the turf density. **Control** A 2,4-D combination herbicide will work best on younger plants. Pre-emergent herbicides such as trifluralin + benefin or dithiopyr applied in spring can provide some control.

Oxalis *Oxalis corniculata* The leaves of oxalis, also called creeping woodsorrel, have a shamrock appearance and the plant is often mistaken for a clover. At night, or on cloudy days, the leaves may fold up. With the arrival of cooler weather in the fall, leaves turn purplish in color. Occasionally, some plants may have purple leaves all year round. Oxalis is a prostrate, creeping perennial weed with stems that will take root where they touch the ground. Flowers are small and yellow. When mature, fruits explode, scattering seed several feet away. This plant is more common in thin, less vigorous turfgrass that is given too-frequent, light irrigation. It can be discouraged by increasing the density of turfgrass using good cultural practices.
Oxalis Control 2,4-D combination herbicides applied in spring and/or fall give marginal levels of control. Triclopyr + clopyralid control is fair to good. Pre-emergent herbicides (pendimethalin, dithiopyr, isoxaben, prodiamine) applied 2-3 successive years in late March - early April can provide some control.

White clover *Trifolium repens*

Buffalo Bur *Solanum rostratum*

Puncture vine *Tribulus terrestris*

Oxalis *Oxalis corniculata*

Redroot Pigweed *Amaranthus retroflexus* **Dandelion** *Taraxacum officinale*

Redroot pigweed is an annual weed commonly found in waste areas and disturbed soils. It can attain a 2-4 foot height. The lower stems are reddish in color. Flowers are small and green, in bristly terminal and axillary clusters. A prolific seed producer, pigweed will produce up to 100,000 seeds per plant. Seedlings are easily pulled or hoed from the garden. Older plants are more difficult to pull out and may scatter seeds in the process. Mulch will prevent seeds already in the soil from germinating.

Control When found in the lawn, pigweed can be spot-treated with herbicides containing MCPP, MCPA, and dicamba. In gardens, glyphosate (Round-up, Kleen-up) can be used, taking care not to get any of the chemical on desired plants. Pre-emergents containing oryzalin, pendimethalin, or trifluralin can be effective. When using a herbicide, be sure to read the label carefully and follow directions closely.

Dandelion The Dandelion is a perennial with an extensive taproot. Its yellow flowers can develop anytime between March and November and are followed by fluffy seed heads. More prevalent under low turf density, dandelion growth can be inhibited by increasing the turf density. Dandelions can be dug out with special tools, but any part of the root that is left is capable of regenerating a plant.

Control A 2,4-D or 2,4-D combination herbicide is most effective and should be used in spring and fall. Always read the label before applying any pesticide.

Curly dock is a perennial weed in the buckwheat family. Fairly pleasant tasting, the leaves are very rich in vitamins, especially vitamins A and C, and can be eaten raw or cooked. The roasted seed has been used as a coffee substitute. It is also a very important food plant for the cater-pillars of many butterflies. In the spring, basal leaves emerge from a stout taproot. These elongated leaves have wavy margins, thus the name "curly" dock. In summer, the plant has reddish, rigid stems, 2-4 feet tall. Flower stems have greenish flowers.

This is a tenacious perennial weed that is found in lawns throughout the United States. Its large taproot grows deep into the soil, which enables it to thrive in times when grass may be suffering from heat and lack of moisture. In fall, winged fruits form on the flowering stems that are reddish-brown in color. Curly dock is not easily pulled because of the deep taproot, and portions of this root left in the ground will regenerate.

Control Combination herbicides containing mecoprop, dicamba and 2,4-D are effective in the control of Curly dock.

Quackgrass, a creeping perennial, is a very aggressive grass and is considered a noxious weed in most states. It spreads by seeds and invasive rhizomes (underground stems). Its rhizomes are yellow-white, with brown sections, and the ends are sharply pointed.

Control A few quackgrass plants can be spot-sprayed with glyphosate, or individual blades can be painted with glyphosate. Note that glyphosate will kill any bluegrass it contacts. Repeat applications to quackgrass will likely be needed. Renovate severely infested lawn areas. Spray with glyphosate; repeat applications will likely be needed. When the quackgrass has been killed, the areas may be re-sodded or re-seeded. Always read the label before applying any pesticide.

Broadleaf Plantain is a low growing perennial. It has broad leaves with prominent veins. The leaves are arranged in a rosette and may smother lawn grass. The flowering spikes normally grow taller than the foliage but may develop below mowing height. Vigorous, thick turfgrass is less susceptible to invasion.

Control Triclopyr + 2,4-D or 2,4-D alone or 2,4-D combination herbicides should control plantain. Always read the label before applying any pesticide.

Quackgrass *Elytrigia repens*

Curly Dock *Rumex crispus*

Broadleaf Plantain *Plantago major*

Common Lambsquarters *Chenopodium album*

Purslane *Portulaca oleracea*

Crabgrass *Digitaria sanguinalis*

Common Lambsquarters is a broadleaf summer-annual weed that can be found anyplace the soil has been disturbed. The growth habits of the common lambsquarters vary with its location. If growing along the road or in an open field, it may reach three or four feet in height. Yet those plants found in lawns may produce seeds when only a couple of inches tall. Lambsquarters prefer rich soil and are often found in vegetable gardens. The first two true leaves that appear are opposite and ovate with smooth edges. Later leaves are alternate, arrowhead-shaped, and with unevenly-toothed edges. At the top of the plant, the leaves become long and narrow. All of the leaves are pale green and covered with white, mealy granules that give the appearance of frost. Stems are erect and often have light-green or red lines. Flowers are small, inconspicuous, yellow-green, and occur in clusters at the tips of branches and upper leaf axils. These flowers occur from July to September. Black seeds are contained in an utricle by a thin papery covering.
Control The best methods of weed control in the home vegetable garden are mulching, hand pulling, rototilling, hoeing and preventing the weeds from going to seed. Because of its short, branched taproot, lambsquarters can be easily hand-pulled from moist soil. Prevention by use of good cultural habits should be the first line of defense in eliminating broadleaf weeds such as lambsquarters from lawns. Pre-emergent herbicides such as trifluralin (Preen) can be used to prevent germination of weed seeds. Post-emergent herbicides effective against broadleaf weeds are 2,4-D, MCPP and dicamba (sold under many brand names) and combination formulas (Trimec). Read labels to be sure the herbicide is effective against the weeds you want to eliminate and follow the directions carefully.

Purslane is a summer annual, found only in newly seeded or thinning, non-vigorous lawns and sidewalk cracks. It has thick, succulent, rubbery leaves and small yellow flowers. The plant is sprawling and prostrate. It is easily pulled when the soil is moist.
Control Post-emergent herbicide use is more effective when plants are young as purslane is difficult to kill with an herbicide when larger. Always read the label before applying any pesticide.

Crabgrass is a summer annual grass with wider blades and a lighter green color than bluegrass. It is low growing, prostrate, and often has reddish-purple stems. It forms seedheads below mowing height. The seedheads are composed of slender, fingerlike spikes. Crabgrass is less prevalent when turf has good density. In particular, mowing too low promotes crabgrass seed germination. Maintain mowing heights of 2.5 - 3 inches.
Control A pre-emergent herbicide (benefin + trifluralin, dithiopyr, DCPA, oxadiazon, pendimethalin, or prodiamine) applied correctly and at the proper time should provide control. Do not use a pre-emergent herbicide on a newly seeded or sodded lawn or when overseeding a lawn. Fenoxaprop and other post-emergent "crabgrass killer" (MSMA, DSMA, MAMA) sprays are not effective unless crabgrass plants are immature, young seedlings. Always read the label before applying any pesticide.

Poison Hemlock (*Conium maculatum*), also known as poison parsley or spotted parsley, is an erect biennial weed that can grow 6 to 10 feet tall. Originally imported from Europe as an ornamental plant, its spread across North America has been rampant. All parts of this plant are poisonous. The leaves and flowers of Poison Hemlock are similar to those of parsnips and carrots. In fact, many deaths have occurred as a result of people mistaking it for the edible species of the carrot family. The use of hemlock as a poison goes back many years in history. It is said that the ancient Greeks used it to poison their enemies and political prisoners. Socrates, condemned to die as a political prisoner in 329 B.C., drank the juice of the hemlock plant and committed suicide. Native Americans were known to dip their arrows in hemlock. Poison Hemlock is an erect plant with smooth, hollow stems that are covered with purple spots. Its shiny green leaves are pinnately compound, multi-stemmed and fern-like in appearance. Flowers are showy, white umbrella-like clusters that occur during June to July. The fruit is small, flat, grayish-green, and matures in August to September.
Control The large, fleshy white taproot can be easily pulled from moist ground when plants are small. Several herbicides are effective in controlling Poison Hemlock. Glyphosate (Roundup) can be used on newly emerged sprouts. Other post-emergents that are most effective in early spring are 2,4-D, 2,4-DB and MCPA. 2,4-D should be combined with a wetting agent when applied. Because of the large number of seeds that may have been produced, repeated herbicide applications may be necessary. The frequency of application varies with the herbicide. Read labels carefully and follow directions as given. Biological control has been effective using the Hemlock moth (*Agonopterix alstroemericana*). The larvae of this moth feed on the leaves, young stem tissue, flowers and seeds of Hemlock plants, causing severe defoliation and death of the plant.

Silverleaf Nightshade *Solanum elaeagnifolium*

Bamboo *Phyllostachys angusta*

Common Mallow *Malva neglecta*

Common Groundsel *Senecio vulgaris*

Silverleaf Nightshade is a member of the Nightshade (or Potato) Family. It grows to 3 feet in height and has silvery, lance shaped leaves with wavy edges which grow to 4 inches in length. The plant typically grows in open areas, such as roadsides and fields, at elevations between 1000-5500 feet. The Silverleaf Nightshade is poisonous; however, Native Americans have used the crushed berries of the plant to curdle milk since they contain a protein-digesting enzyme. Silverleaf Nightshade typically blooms between May - October and produces a bluish purple, star shaped flower with yellow anthers in the middle to 1.5 inches in width. The flower is followed by a 1/2 inch diameter yellow berry.
Control Cobra ® may be used in combination with MSMA, Bladex® and Karmex® to aid in control of certain weeds. Consult specific product labels for recommendations and precautions.

Bamboo - Phyllostachys: From the Greek "*phyllon*", leaf, and "*stachys*", a spike, referring to the leafy bloom spike (inflorescence). Subfamily: ***Bambusoideae*** A diverse genus of about 15 species of evergreen running bamboo primarily native to temperate and subtropical China and Japan,

Phyllostachys includes several popular bamboo of gardens as well as varieties valued for timber and for edible shoots. The rounded culms display distinctive grooves or compressed areas on the branching sides, making this genus fairly easy to recognize and distinguish from other bamboo. Their dense evergreen foliage, attractively marked and colored culms, and fast growth have made these running bamboos favorites for creating large groves, for screening and hedging, and for stabilizing rough slopes or streamsides. On small properties the spreading roots of ***Phyllostachys*** may be confined as desired by installing appropriate barriers at planting.

Culture: ***Phyllostachys*** species thrive in sun or light shade if provided with abundant moisture and rich soil. Where drought may be expected or in hot interior climates, some shading would be beneficial for most varieties. Established plants withstand flooding.

Control Bamboo can be controlled in a small area (a normal city yard) simply by mowing or stepping on the young shoots. New shoots could also be used for culinary purposes and cooked, much like asparagus. Keep in mind that running bamboo only puts up new shoots for a short time each year, and when they are "shooting", the new plants are very fragile and easy to destroy. To really slow the spread of the rhizomes, the grove can be root pruned at any time. (Best time seems to be in the fall or early winter). This is done with a sharp, narrow spade (8" wide, flat spade works quite well) by "trimming" the rhizomes on all sides which need to be controlled. Push the shovel straight down to its maximum depth so as to cut through any rhizomes encountered, (8-10 inches is usually sufficient). Keep moving the spade one width at a time to the right or left, cutting a line until all the rhizomes have been cut. Yes, you may miss a few, but you can get them next year. You do not have to dig up the whole root system and rhizomes. Once you have severed it from the mother plant and cut off any new shoots, you will have deprived it of all food sources and it will die off. Glyphosate (Roundup, Kleenup) Systemic type: Controls a wide range of annual and perennial grasses and broadleaf plants, but in many cases requires very precise timing to be effective.

Common mallow is most frequently found in newly seeded lawns or lawns that are stressed and lack density. It can be an annual or biennial. Mallow has a deep taproot but can be easily pulled from moist soil. The foliage resembles that of the geranium. The flowers of common mallow are pinkish-white and the fruits look like small, round cheeses.

Control Increasing turf density with proper mowing, fertilization, watering and other cultural practices can help in the control of this weed. Post-emergent herbicides are only marginally effective. Triclopyr + clopyralid or triclopyr alone are suggested.

Common groundsel is an early season weed. A prolific seed producer, seeds are produced within several weeks of germination, and there are several generations within the same year. This weed likes moist soil and is often found in well-irrigated areas such as lawns and flower beds.

Control A dense, healthy turf will prevent seeds from taking root in the lawn. Turf density can be increased with proper mowing, fertilization, watering, and other cultural practices. Good drainage will also help to discourage the growth of common groundsel. The plants can be easily pulled by hand from moist soil. Be sure to pull and dispose of them before they set seed, as seed can mature in opened flowers even after the plants have been killed. If there is heavy infestation, spot treat with a post-emergent herbicide containing glyphosate (Roundup, Kleenup).

Redstem Filaree *Erodium cicutarium*

London Rocket *Sisymbrium irio*

Russian Thistle *Salsola iberica*

Milkweed *Asclepias syriaca*

Redstem Filaree is a prostrate broadleaf winter annual or biennial weed. A member of the geranium family, it has fern-like, or feathery appearing foliage in a rosette. The stems are reddish and there is a large, white taproot.

Control Appearing more frequently in newly seeded lawns or thin, stressed lawns, this minor turf weed can be eliminated by increasing the density of the lawn. Newly seeded lawns will develop more density with time and will then crowd out this weed. It is often seen in buffalograss lawns. The entire plant can be easily pulled out of moist ground. Post emergent herbicides such as 2,4-D or 2.4-D combinations are only marginally effective in controlling Redstem Filaree.

London rocket is a European native weed belonging to the mustard family, and is one of the first winter weeds to appear in southern Arizona. It is abundant in irrigated land in crops such as alfalfa and small grains, in gardens, citrus orchards, pastures, and along roadsides. London rocket is a bright green fleshy winter annual. The stems branch from the base 1 to 3 feet high. It has a coarse taproot. Small, yellow flowers are borne on slender stalks in small clusters at the stem tip.

Russian thistle was introduced from Russia and is an annual which reproduces by seed. It is a round, bushy, much-branched plant, growing 1 to 3-1/2 feet high. The branches are slender, succulent when young, and woody when mature. Russian thistle grows on dry plains, in cultivated fields, roadsides, and waste places, chiefly in grain-growing areas. At maturity, the plant breaks off at the base and because of its round shape, becomes an excellent tumbleweed. Russian thistle is an annual. A single plant may produce 20,000 to 50,000 seeds. Seeds germinate quickly, even after brief or limited precipitation. The plants are well branched, round bushy that grow 1/2 to 3 feet high. The stems have reddish or purple strips. The leaves are alternate, long, and very thin or needle-like. Flowers are small and inconspicuous and develop in the upper leaf axils. Each flower has a pair of spiny bracts. Mature plants break off at ground level and tumble, spreading the seeds. This species is a host of sugar beet leafhopper, which transmits curly top of sugar beets. This weed is common in drier areas and in dry land cultivation systems. It is found in overgrazed rangeland, disturbed waste areas and in wheat, sugar beet, potato, and mint crops east of the Cascade Mountains.

Control Control of Russian thistle is difficult. There have been numerous attempts through the years to import biological control agents, but none have been successful.

Pre-emergent herbicides are applied to the soil before the weed seed germinates and are usually incorporated into the soil with irrigation or rainfall. The most effective pre-emergent herbicides are Aatrex (atrazine), Velpar (hexazinone), Devrinol (napropamide), Telar (chlorsulfuron), Oust (sulfometuron), Princep (simazine) and Hyvar (bromacil). Other pre-emergent herbicides that are registered but only moderately effective in controlling Russian thistle are Surflan (oryzalin), Treflan (trifluralin), Prowl (pendimethalin), Endurance (prodiamine), Lasso (alachlor), Predict (norflurazon), and Kerb (pronamide).
Herbicide-resistant biotypes of Russian thistle have evolved in only a couple of years following treatment with Telar (chlorsulfuron) or Oust (sulfometuron). Avoid repeated use of a single herbicide or of herbicides that have the same mode of action to prevent the evolution of herbicide-resistant populations.

Post-emergent herbicides are applied to plants, but timing is critical. For best results, these herbicides must be applied while the weed is in its early growth stages, preferably the early seedling stage, before it becomes hardened and starts producing its spiney branches. Do not use post-emergent herbicides to try to control the mature seed (either on the plant or on the ground) as they are not effective for this purpose. Also, the later spiney stage of Russian thistle is not readily controlled by any post-emergent herbicide. If rain or irrigation occurs after a post-emergent application, additional seedlings may emerge and require future treatments. Post-emergent herbicides that are effective when properly applied include Banvel or Vanquish (dicamba), Roundup (glyphosate), 2,4-D and Gramoxone (paraquat).

Milkweed plants, members of the Asclepias family, are the only host plant for the monarch and queen butterflies. The adult females seek out these plants on which they lay their eggs. The caterpillars that hatch will remain on the plants and eat the leaves until they enter the pupal stage, then emerge as adult butterflies. It is a perennial herb with long-spreading rhizomes. Stems are stout, erect, to 2 m tall, with short downy hairs and milky juice; leaves opposite, oblong, rounded, 1–2.6 dm long, 0.4–1.8 dm broad, with prominent veins; upper surface smooth, lower covered with short white hairs and strong transverse nerves. Flowers sweet-smelling, pink to white, in large, many-flowered, axillary and apical bell-like clusters; corolla lobes 6–9 mm long, hoods 3–4 mm high; follicle grayish, hairy, with soft spiny projections, 1–3 mm high, slenderly ovoid, 2.5– 3.5 cm thick. Seed brown, flat, oval, 6 mm long, 5 mm wide, with a tuft of silky white hairs apically (Reed, 1970)
Control Non-Cropland -- Established stands of common milkweed can be controlled with herbicides. On non-cropland (i.e., roadsides, railroad rights-of-way, etc., but not idle land or grazing land), Amitrol-T, Roundup or Tordon would provide control. Herbicide coverage of the common milkweed is incomplete with this method, resulting in reduced effectiveness compared to a sprayer. Used over several years, however, common milkweed populations can be reduced with Roundup applied in a wiper applicator. Controls: Amino Trizole; Amitrol-T, Roundup, 2,4-D+Banvel,and Tordon

Hops Clover *Trifolium dubium*

Trifolium dubium (formerly T. minus) goes by several common names, including Least Hops Clover, Small Hops Clover, Lesser Trefoil, Yellow Shamrock, & Kleiner Klee. The tiny flowers are said to resemble h Hops Clover hops.

It is a very common mat-forming weed which erupts on roadsides & empty lots early in spring in recently disturbed soil or wherever grass, including wild meadow grasses, was chopped short at the end of the previous year. It is only two to six inches tall, so tries to get a head start on larger plants, germinating its previous year's seeds in January or February.

It can be the dominant weed or miniature wildflower in April. Though it may still be blooming May through July, other plants will have grown so much as to hide it, & the early-spring mats will be overwhelmed by larger weeds & grasses. But it will still be seen until at least early July, popping up in cleared gardening areas.

It is easily mistaken for another common wildflower, Black Medick (Medicago lupulina, but Black Medic's wee yellow flowers turn into a cluster of tiny kidney-shaped black seeds, & its trifoil leaves have pointy tips. Black Medic's range is world-wide, & Least Hops Clover is only slightly less universal in its distribution. Both plants became distributed throughout the world at least a century ago, when sailing ships routinely picked up alfalfa bales from Eurasia & Central Asia to use as passing fill-in between more profitable shipments, then sold the bales to farmers in ports of the New World & Pacific Islands. Sundry knapweeds also spread throughout the world from this practice.

Like other clovers & legume family plants generally, Hops Clover helps bind nitrogen in poor soils. Though some people fight it as an unwanted weed, it is in reality doing the soil a good deed. Though adaptable to a wide range of conditions, it tends to die out of rich soils, & does not compete well with big perennials. But for the most part, it cannot be gotten rid of, so it might as well be appreciated for the real charm of so many teensy bright yellow flowers & miniature trifoil leaves. While Hops Clover annoys people who want perfection in their lawns, others never even notice it is all over the place. It is too small to make a particularly big display. It is one of the smallest of clovers, though even at that, the tiny flowers are actually made up of about two-dozen even more wee florets.

Common Weed Related Terms

The terms listed below are used in this course to describe herbicide applications:

Active ingredient (ai) – The chemical in a herbicide formulation primarily responsible for its phytotoxicity and which is identified as the active ingredient on the product label.

Acid equivalent (ae) – Expresses the rate or quantity as the herbicidally active parent acid. For example, 2,4-D acid is formulated with either sodium, an amine, or an ester to make the active ingredient salt sold as a formulated product. The active acid equivalent per gallon of a widely used ester formulation is 3.8 lb. ae/gal while the active ingredient is 6.0 lb. ai/gal.

Band application – Herbicide applied to a narrow strip centered over the crop row.

Broadcast application – Herbicide applied over entire area.

Directed spray application – Herbicide applied to a band along the row that includes the base of crop plants and the weeds in the row. Spray is directed across the row from nozzles positioned near ground level on each side of the row. This type of application allows use of chemicals that will injure the crop plant if more than a small part of the plant is contacted by spray. Special units that guide from the ground or mount on cultivators must be used.

Drop-nozzle application – Herbicide applied by means of nozzles mounted on extensions below the spray boom to avoid spraying upper parts of the crop plant.

Formulation – Refers to the form in which a herbicide is purchased. Common forms are liquids, granules, and wettable powders which contain added ingredients to improve storage, mixing, or application characteristics of the herbicides.

Post-emergence application – Herbicide applied to the crop and weeds after they emerge.

Pre-emergence application – Herbicide applied after a crop is planted but before it or weeds emerge.

Pre-planting application – Herbicide applied before the crop is planted.

Rate – The amount of active ingredient or acid equivalent of an herbicide applied to the area treated, that is, on a broadcast basis.

Soil incorporation – Mechanical mixing of the herbicide with the soil. Chemicals may be incorporated 2 to 4 inches with a disk or rotary tiller, 1 to 2 inches with a harrow or rotary hoe, or slightly covered with planter attachments. The desired depth of incorporation depends on characteristics of the chemical being used.

Topic 1 Weed Identification Section Post Quiz
Answers at the rear of Glossary

Fill-in-the-blank

1. _____germinate from seed, grow, flower, and produce seed in less than one year.

2. _____(AKA warm season annuals) germinate in the spring and mature in the fall, whereas winter annuals (AKA cool season annuals) germinate in fall or late winter and mature in late spring.

3. _____ complete their lifecycle from seed to maturity in less than one year. They germinate in the spring, mature, set seed and die in the fall.

4. The noxious weeds mandated for control are _____to North America. Consequently, these plants do not have the natural checks as found in their native land, such as insects, diseases, and herbivores that would keep the plant population in check.

Understanding Weed Terms

5. Ecovar: Short for “ecological variety.” A plant “variety” developed by man from a collection of plants of a _____ that were selected from several to many natural populations in a specific region.

Importance of Native Plants

6. The populations of many native plants have been greatly reduced as a result of human encroachment which has destroyed many millions of acres of natural habitat. In the U.S. alone, about 200 native plant species have become _____since the 1800's and 5,000 species are considered to be at risk.

Broadleaves (dicots), Grasses (monocots), and Sedges

7. Cotyledons have various shapes and sizes; they may be _____shaped or have variations of each. Look at other features of the weed, such as the true leaves (leaves emerging after cotyledons) and stems.

8. Puncture vine is a prostrate, mat-forming summer annual. It has small leaflets and small yellow flowers with 5 petals. Fruits containing seeds are a sharp, spiny burr that can easily puncture a bicycle inner tube (or gardener’s skin!). This weed is found only in_____. It will pull easily out of moist soils. Be sure to wear gloves to protect your hands from the burrs. You can discourage the growth of puncture vine by increasing the turf density.

9. Curly dock is a perennial weed in the_____. Fairly pleasant tasting, the leaves are very rich in vitamins, especially vitamins A and C, and can be eaten raw or cooked. The roasted seed has been used as a coffee substitute. It is also a very important food plant for the cater-pillars of many butterflies. In the spring, basal leaves emerge from a stout taproot. These elongated leaves have wavy margins, thus the name "curly" dock. In summer, the plant has reddish, rigid stems, 2-4 feet tall. Flower stems have greenish flowers.

10. Milkweed plants, members of the_____, are the only host plant for the monarch and queen butterflies. The adult females seek out these plants on which they lay their eggs. The caterpillars that hatch will remain on the plants and eat the leaves until they enter the pupal stage, then emerge as adult butterflies. It is a perennial herb with long-spreading rhizomes.

Topic 2 Invasive Plant Species Introduction

Invasive species can be plants, animals, and other organisms (e.g., microbes). Human actions are the primary means of invasive species introductions.

What is an Invasive Plant?
An invasive plant has the ability to thrive and spread aggressively outside its natural range. A naturally aggressive plant may be especially invasive when it is introduced to a new habitat. An invasive species that colonizes a new area may gain an ecological edge since the insects, diseases, and foraging animals that naturally keep its growth in check in its native range are not present in its new habitat.

Some invasive plants are worse than others. Many invasive plants continue to be admired by gardeners who may not be aware of their weedy nature. Others are recognized as weeds but property owners fail to do their part in preventing their spread. Some do not even become invasive until they are neglected for a long time. Invasive plants are not all equally invasive. Some only colonize small areas and do not do so aggressively. Others may spread and come to dominate large areas in just a few years. Below are some categories to illustrate degree of invasiveness.

Danger! Don't plant it...
Purple Loosestrife, Lythrum salicaria, has long been a prized perennial. Its pinkish-purple flowers appear over a long period in summer. The seeds of this plant easily wash into waterways, and can be carried in the mud on the feet of waterfowl. Stands of loosestrife spread exponentially in wetlands and along stream beds. This plant should be removed by hand only if it is very young. Attempts to dig it out usually backfire because purple loosestrife resprouts from root fragments; disturbing the soil just provides more room for it to spread. Cut established plants to the ground periodically to prevent flowering. Other invasive plants such as Tartarian honeysuckle, Lonicera tatarica; Russian olive, Elaeagnus angustifolia; and Siberian elm, Ulmus pumila, are still available for planting even though they have become invasive over large areas. This category is threatening because gardeners who are unaware of problems with these plants may still be planting them in areas that have not yet been colonized.

Warning: If you see it, remove it...
Tree-of-heaven, Ailanthus altissima, is one of the few trees that can grow in abandoned alleys, gutters, and broken sidewalks, or just about anywhere that is not in shade. It grows very quickly, and competes aggressively for sunlight in newly developing forests. Disturbed sites are often dominated by tree-of-heaven. Pull these seedlings whenever you see them; once they have grown for a few years they are extremely difficult to get rid of. Reducing the number of trees will reduce the yearly output of seeds. Other common weeds which are invasive plants are multiflora rose, Rosa multiflora; garlic mustard, Allaria petiolata; and lesser celandine, Ranunculus ficaria. Although these plants are not often planted intentionally in gardens or offered for sale, they have the ability to spread if not controlled.

Caution: It's not a problem if you manage it wisely...
English ivy, Hedera helix, is one of the most popular ground covers in North America. However, its potential for escape is notorious. In the Pacific Northwest, English ivy invades the forest floors. Its evergreen leaves smother other native forest plants by denying them light. Interestingly, English ivy only reaches maturity and goes to seed after it has grown up a vertical surface. If you are willing to prune it regularly to contain it, it does not pose a threat. English ivy is not a good choice, though, if you want a low maintenance garden. You may want to replace it with native plants such as lowbush blueberry, Vaccinium angustifolium; alum root, Heuchera americana; or partridge berry, Mitchella repens. Some other invasive exotics aside from English ivy that fit this category are common daylily, Hemerocallis fulva; butterfly bush, Buddleia spp.; wintercreeper, Euonymus fortunei; and lilyturf, Liriope muscari.

Although these plants are invasive, they can still be enjoyed by gardeners who want to grow them if they are willing to devote the time and effort to careful stewardship to prevent their spread.

Where are they a problem?
Invasive plants disrupt many natural habitats. They are most threatening in ecosystems such as wetlands, sand dunes, fire prone areas, and serpentine barrens where rare native plants are found. Invasive plant species thrive where the continuity of a natural ecosystem is breached and are abundant on disturbed sites like construction areas and road cuts. Even foot traffic can create a temporary void that is quickly invaded– some national parks have restricted the areas where visitors are allowed to walk with the warning, "we can watch purple loosestrife grow from people's footsteps."

Why are they a problem?
It's a matter of ecology. In many cases, plants from other parts of the world are welcomed, manageable additions to our gardens. However, in some situations these non-native species cause serious ecological disturbances. In the worst cases, invasive plants like mile-a-minute, purple loosestrife, and kudzu ruthlessly choke out other plant life. This puts extreme pressure on native plants and animals, and threatened species may succumb to this pressure. Ultimately, invasive plants alter habitats and reduce biodiversity.

Where do they come from?
In some cases, invasive plants arrive purely by accident, as seed in agricultural products, or on shipments from overseas. In other cases, invasive plants are selected for their horticultural attributes. Beautiful, unusual, exceptionally hardy, drought-tolerant, or fast-growing plants are sought by gardeners the world over. Unfortunately, plants selected for their resilience may be invasive because of their adaptable nature. Plants selected for their aesthetic value may be hard to banish from your garden even after their invasive tendencies are revealed.

Invasive Plants:
- Produce large numbers of new plants each season.
- Tolerate many soil types and weather conditions.
- Spread easily and efficiently, usually by wind, water, or animals.
- Grow rapidly, allowing them to displace slower growing plants.
- Spread rampantly when they are free of the natural checks and balances found in their native range.

What Can You Do?
Contact your local native plant society or state Department of Natural Resources to find out which plants are invasive in your area.
- Learn to identify locally important invasive plants.
- Remove invasive plants on your property or prevent their spread.
- Only use non-invasive plants when landscaping your property.
- If your property borders a natural area, consider using only native plants in your landscape.
- Find non-invasive or native alternatives for invasive landscape plants.
- Use systemic herbicides carefully as a last resort to remove invasive plants.
- Make others in your neighborhood aware of invasive plants.

Invasive Plants are a Problem throughout the Country

Here are some of the most commonly encountered invasive plants and the areas where they are a problem:

Elaeagnus angustifolia Russian olive	western U.S.
Melaleuca quinquenervia Cajeput tree	wetlands, southern Florida
Lythrum salicaria purple loosestrife	wetlands, most of U.S.
Ailanthus altissima tree-of-heaven	most of U.S.
Lonicera japonica Japanese honeysuckle	eastern U.S. to Midwest
Pueraria lobata kudzu	southeastern U.S.
Euphorbia esula leafy spurge	Midwest to West
Polygonum perfoliatum mile-a-minute	NY to VA and WV
Tamarix ramosissima tamarisk	western U.S.
Imperata cylindrica cogongrass	Gulf Coast states

As defined by the Oregon Invasive Species Council

Next to habitat lost to land development and transformation, invasive species pose the greatest threat to the survival of native biota in the United States, and many other areas of the world. Invasive species are those plants, animals, and microbes not native to a region which, when introduced either accidentally or intentionally, out-compete native species for available resources, reproduce prolifically, and dominate regions and ecosystems. Because they often arrive in new areas unaccompanied by their native predators, invasive species can be difficult to control. Left unchecked, many invasives have the potential to transform entire ecosystems, as native species and those that depend on them for food, shelter, and habitat disappear.

Perception to Cause Harm

Complications concerning the concept of *invasive species* arise from differing human values and perspectives. Differing perceptions of the relative harm caused or benefit gained by a particular organism are influenced by different values and management goals. If *invasive species* did not cause harm, we would not be nearly as concerned. Perceptions of relative benefit and harm also may change as new knowledge is acquired, or as human values or management goals change.

For a non-native organism to be considered an *invasive species* in the policy context, the negative effects that the organism causes or is likely to cause are deemed to outweigh any beneficial effects.

Many non-native introductions provide benefits to society and even among species that technically meet the definition of invasive, societal benefits may greatly exceed any negative effects (for example crops and livestock raised for food). However, in some cases any positive effects are clearly overshadowed by negative

effects, and this is the concept of causing harm. For example, water hyacinth has been popular in outdoor aquatic gardens but its escape to natural areas where its populations have expanded to completely cover lakes and rivers has devastated water bodies and the life they support, especially in the southeastern U.S. And, there are some organisms, such as West Nile virus, that provide almost no benefits to society at all. Such organisms constitute a small fraction of non-native species, but as a consequence of their ability to spread and establish populations outside their native ranges, they can be disastrous for the natural environment, the economies it supports, and/or public health. Because *invasive species* management is difficult and often very expensive, these worst offenders are the most obvious and best targets for policy attention and management.

The negative impact to a native species caused by an *invasive species* might trigger additional negative interactions for other associated native species; i.e., there could be direct and indirect effects. For example, an invasive weed that is undesirable as a food source may outcompete and displace native grasses and broadleaf plants. These displaced native grasses and broadleaf plants may have been primary forage for animals, which subsequently would be displaced to a new location or have their populations reduced because the weed invasion decreased the availability of food in their native plant and animal community. However, negative effects are not always characterized by a cascade of impacts realized throughout the environment. For example, simple displacement of an endangered species by a non-native species might alone provide sufficient justification to consider the non-native organism an *invasive species*.

What We Do Not Mean, What We Do Mean, and the "Gray" Area
Native and Non-native Species
Invasive species are species not native to the ecosystem being considered. Canada geese are native to North America and most of their populations migrate annually. However, in some locations in the U.S. (e.g. suburban Maryland; the Front Range of Colorado) introduced, non-migratory populations of Canada Geese are causing problems – such as fouling lawns, sidewalks, grass parks, and similar areas. While non-migratory populations can cause problems, they are not considered an *invasive species* because they are native.

Additionally, Canada geese are of significant financial value to many local economies through waterfowl hunting and simple enjoyment. Mute swans, however, are invasive. Mute swans are native to Europe and Asia but were introduced into North America where their populations have increased dramatically. They compete directly with native waterfowl for habitat, displacing them, and that is why they are considered an *invasive species*. Whitetail deer populations have increased dramatically in the northeastern U.S. and are problems in farms, yards, and natural areas because they consume plants valued by humans; but are not invasive because they are native.

Environmental Harm
We use environmental harm to mean biologically significant decreases in native species populations, alterations to plant and animal communities or to ecological processes that native species and other desirable plants and animals and humans depend on for survival. Environmental harm may be a result of direct effects of *invasive species*, leading to biologically significant decreases in native species populations.

Examples of direct effects on native species include preying and feeding on them, causing or vectoring diseases, preventing them from reproducing or killing their young, out-competing them for food, nutrients, light, nest sites or other vital resources, or hybridizing with them so frequently that within a few generations, few if any truly native individuals remain. Environmental harm includes decreases in populations of Federally Listed Threatened and Endangered Species, other rare or uncommon species and even in populations of otherwise common native species.

For example, over three billion individual American chestnut trees were found in U.S. forests before the invasive chestnut blight arrived and virtually eliminated them. Environmental harm also can be the result of an indirect effect of invasive species, such as the decreases in native waterfowl populations that may result when an invasive wetland plant decreases the abundance of native plants and thus, decreases seeds and other food that they provide and that the waterfowl depend upon.

Environmental harm also includes significant changes in ecological processes, sometimes across entire regions, which result in conditions that native species and even entire plant and animal communities cannot tolerate. For example, some non-native plants can change the frequency and intensity of wildfires, or alter the hydrology of rivers, streams, lakes and wetlands and that is why they are considered *invasive species*. Others can significantly alter erosion rates. For example, trapping far more wind-blown sand than native dune species, or holding far less soil than native grassland species following rainstorms. Some invasive plants and micro-organisms can alter soil chemistry across large areas, significantly altering soil pH or soil nutrient availability. Environmental harm also includes significant changes in the composition and even the structure of native plant and animal communities. For example, the invasive tree *Melaleuca quinquinervia*, can spread into and take over marshes in Florida's Everglades, changing them from open grassy marshes to closed canopy swamp-forests.

Environmental harm may also cause or be associated with economic losses and damage to human, plant and animal health. For example invasions by fire promoting grasses that alter entire plant and animal communities eliminating or sharply reducing populations of many native plant and animal species, can also lead to large increases in fire-fighting costs and sharp decreases in forage for livestock. West Nile virus is a well-known human health problem caused by a non-native virus which is commonly carried by mosquitoes. West Nile Virus also kills many native bird species, causing drastic reduction in populations for some species including crows and jays.

Additional Examples of Impacts Caused by Invasive Species
Specific examples of the harm caused by *invasive species* are useful to further clarify the definition. The following list of examples is not meant to be comprehensive, but offers further explanation:

Impacts to Human Health
Respiratory infections: The outbreak of *West Nile virus* in the U.S. began in the Northeast in 1999 and has since spread throughout the country. Infections in humans may result in a flu-like illness and in some cases death. This outbreak has caused illness in thousands of citizens, increased medical costs for affected persons, and decreased productivity due to absence from work. *West Nile virus* also has affected horses and has caused widespread mortality in native birds (U.S. Centers for Disease Control, 2006).

Poisonous plants: Exposure to the sap of *Tree-of-heaven/Chinese sumac tree* has caused inflammation of the heart muscle (myocarditis) in workers charged to clear infested areas. Afflicted personnel experienced fever/chills, chest pain that radiated down both arms, and shortness of breath. Exposure occurred when sap from tree-of-heaven contacted broken skin. Such exposure has caused hospitalization, medical expense, and lost productivity due to absence from work (Bisognano et al. 2005).

Impacts to Natural Resources
Declines in wildlife habitat and timber availability: *Chestnut blight* is a disease of American chestnut caused by a non-native fungal pathogen that was introduced into eastern North America around 1910. The disease eliminated the American chestnut from eastern deciduous forests thereby decreasing timber harvests and wildlife that depended upon the American chestnut for habitat (USDA-APHIS/FS 2000)**.**

European gypsy moth defoliates trees on millions of acres of northeastern and mid-western forests. It currently is found in 19 states causing an estimated $3.9 billion in tree losses and also decreased wildlife habitat (USDA-APHIS/FS 2000).

Decreased soil stabilization and interrupted forest succession: *White pine blister rust* is a disease of white pine species caused by the non-native fungal pathogen *Cronartium ribicola*. It was introduced into eastern North America around 1900 and western North America in 1920. It spread rapidly, killing off native white, white bark, and limber pines, whose seeds are an important food source for birds, rodents and bears.

Elimination of these trees caused by this pathogen alters forest ecosystems, eliminates wildlife forage, and decreases the soil stabilization effects of these trees, snowmelt regulation, and forest succession (Krakowski et al. 2003).

Changes in wildfire frequency and intensity: C*heatgrass* decreases the interval between the occurrences of wildfires in the Great Basin region from once every 70 to 100 years to every 3 to 5 years because it forms dense stands of fine fuel annually. The decrease in interval between wildfires causes increased risk to human life and property and also places at risk established communities of plants and animals that we consider desirable (Knapp 1996; Pimentel et al. 2000; USFWS 2003; Whisenant 1990).

Excessive use of resources: *Tamarisk* in the desert southwest use more than twice as much water annually as all the cities in southern California, which places this invasive weed in direct competition with humans for the most limiting resource in the southwestern U.S. (Friederici 1995; Johnson 1986).

Suppressors: *Russian knapweed* exudes toxins from its tissues that inhibit the growth of surrounding plants or eliminates them. Desirable plant communities are placed at risk from *Russian knapweed* invasion, which may result in decreased numbers of wildlife species or livestock that the invaded land otherwise could support. *Russian knapweed* also is very toxic to horses (Stevens 1986; Young et al. 1970a and 1970b).

Decreased carrying capacity for wildlife and livestock: Expansion of *leafy spurge*, *yellow star thistle* or other unpalatable invasive weeds displace desirable forage plants and may allow fewer grazing animals to survive in infested areas (DiTomaso 2001; Lym and Messersmith 1985; Lym and Kirby 1987).

Impacts to Recreational Opportunities and Other Human Values

Decreased property values: *Asian longhorned beetles* first appeared in New York in 1996 and in Chicago in 1998. Larvae burrow into trees causing girdling of stems and branches, dieback of the crown, and can kill an entire tree. It infests many different tree species in the U.S. and is a threat to urban and rural forests (Cavey et al. 1998).

Emerald ash borers were first detected in the U.S. in 2002. They currently are found in Michigan, Ohio, and Indiana. Emerald ash borer larvae tunnel under bark of ash trees and could eliminate ash as a street, shade, and forest tree throughout the U.S. Estimated replacement cost in six Michigan counties is $11 billion and an additional $2 million in lost nursery sales (Chornesky et al. 2005).

Dutch elm disease was first introduced into the U.S. in 1927 and occurs in most states. Dutch elm disease has killed more than 60% of elms in urban settings and decreased the value of urban and suburban properties (Brasier and Buck 2001).

Spotted knapweed and *leafy spurge* expansion in the western U.S. have displaced desirable forage plants thereby decreasing the value and sales price of grazingland in the western U.S. (Maddox 1979; Weiser 1998).

Eurasian watermilfoil was introduced into the U.S in the 1940s and has since spread throughout much of the country. This submersed aquatic plant can form dense mats at the water surface limiting access, recreation, and aesthetics and thus, has decreased the values of shoreline properties in New Hampshire, the Midwest and elsewhere (Halstead et al. 2003).

Decreased sport fishing opportunities: *Whirling disease* is caused by a parasite (*Myxobolus cerebralis*) that most likely originated in Europe. It was first observed in the U.S. in 1958. The parasite attacks the soft cartilage of young trout causing spinal deformities and causes the fish to exhibit erratic tail-chasing behavior. Heavily infected young trout can die from *Whirling disease* and even if they recover, they remain carriers of the parasite.

All species of trout and salmon may be susceptible and angling and the businesses supported by trout and salmon fishing may be at risk if this disease continues to spread (Aquatic Nuisance Species Task Force et al. 2005; Colorado Division of Wildlife 2006).

Smallmouth bass fishing in Lake Erie was closed during bass mating because of *round goby* predation of nests. Fishing was closed because male smallmouth bass aggressively guard nests from predators and are easier to catch by anglers during this time of year.

Removal of males by anglers decreased the number of bass offspring because of increased *round goby* predation of unguarded nests (Steinhart et al. 2004). Businesses that smallmouth bass anglers patronize could be adversely affected by such closures.

Altered business opportunities: The concern over *Sudden Oak Death Syndrome* caused by the pathogen *Phytophthora ramorum* is causing drastic changes in available nursery stock by nurseries and landscape businesses. This clearly impacts the profitability of these businesses and choice by consumers and could devastate oak forests nationwide (Chornesky et al. 2005; Rizzo and Garbelotto 2003).

Summary

Invasive species are those that are not native to the ecosystem under consideration and that cause or are likely to cause economic or environmental harm or harm to human, animal, or plant health. Plant and animal species under domestication or cultivation and under human control are not *invasive species*. Furthermore for policy purposes, to be considered invasive, the negative impacts caused by a non-native species will be deemed to outweigh the beneficial effects it provides.

Finally, a non-native species might be considered invasive in one region but not in another. Whether or not a species is considered an *invasive species* depends largely on human values. By attempting to manage *invasive species*, we are affirming our economic and environmental values. Those non-native species judged to cause overall economic or environmental harm or harm to human health may be considered invasive, even if they yield some beneficial effects. Society struggles to determine the appropriate course of action in such cases, but in a democratic society that struggle is essential.

Many *invasive species* are examples of "the tragedy of the commons," or how actions that benefit one individual's use of resources may negatively impact others and result in a significant overall increase in damage to the economy, the environment, or public health. In ISAC’s review of Executive Order 113112, the public domain is specifically represented; however, the implementation of the NISMP has prompted concerns over the rights of personal and private property owners. Property rights are of great importance in the U.S. and one outcome of the NISMP should be to recognize the right to self-determination by property owners and promote collaboration on *invasive species* management.

The right to self-determination is an important concept in a democratic society, however, with that right comes personal responsibility and stewardship, which includes being environmentally responsible. The natural environment that our society enjoys, recreates in, and depends upon to support commerce must be conserved and maintained. Effective *invasive species* management is just one aspect of conserving and maintaining our nation’s natural environment, the economies it supports, and the high quality of life our society enjoys.

Inventory Categories

Each plant on the list received an overall rating of High, Moderate or Limited based on evaluation using the criteria system. The meaning of these overall ratings is described below. In addition to the overall ratings, specific combinations of section scores that indicate significant potential for invading new ecosystems triggers an Alert designation so that land managers may watch for range expansions.

Some plants were categorized as Evaluated But Not Listed because either we lack sufficient information to assign a rating or the available information indicates that the species does not have significant impacts at the present time.

- **High** – These species have severe ecological impacts on physical processes, plant and animal communities, and vegetation structure. Their reproductive biology and other attributes are conducive to moderate to high rates of dispersal and establishment. Most are widely distributed ecologically.

- **Moderate** – These species have substantial and apparent—but generally not severe—ecological impacts on physical processes, plant and animal communities, and vegetation structure. Their reproductive biology and other attributes are conducive to moderate to high rates of dispersal, though establishment is generally dependent upon ecological disturbance. Ecological amplitude and distribution may range from limited to widespread.

- **Limited** – These species are invasive but their ecological impacts are minor on a statewide level or there was not enough information to justify a higher score. Their reproductive biology and other attributes result in low to moderate rates of invasiveness. Ecological amplitude and distribution are generally limited, but these species may be locally persistent and problematic.

- ***Wildlands*** are public and private lands that support native ecosystems, including some working landscapes such as grazed rangeland and active timberland.

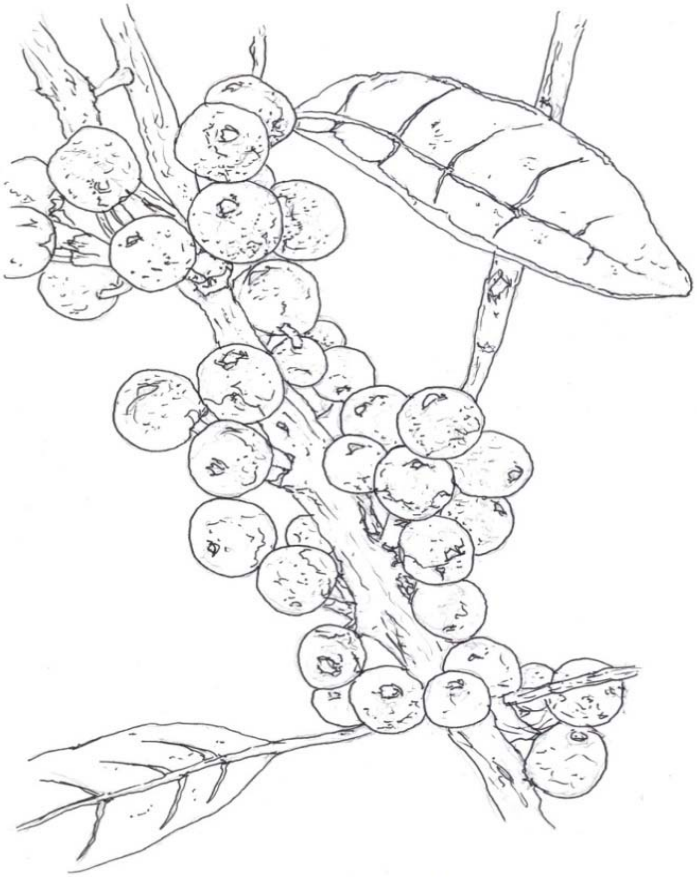
- ***Non-native plants*** are species introduced after European contact and as a direct or indirect result of human activity.

- ***Invasive non-native plants that threaten wildlands*** **are** plants that 1) are not native to, yet can spread into, wildland ecosystems, and that also 2) displace native species, hybridize with native species, alter biological communities, or alter ecosystem processes.

Offical Federal Invasive Plant Listing as of 2013

Air Potato (Dioscorea bulbifera)
Autumn Olive (Elaeagnus umbellata)
Beach Vitex (Vitex rotundifolia)
Brazilian Peppertree (Schinus terebinthifolius)
Canada Thistle (Cirsium arvense)
Chinese Tallow (Triadica sebifera)
Cogongrass (Imperata cylindrica)
Common Buckthorn (Rhamnus cathartica)
Common Teasel (Dipsacus fullonum)
Dalmatian Toadflax (Linaria dalmatica)
Diffuse Knapweed (Centaurea diffusa)
Downy Brome (Bromus tectorum)
Fig Buttercup (Ficaria verna)
Garlic Mustard (Alliaria petiolata)
Giant Hogweed (Heracleum mantegazzianum)
Golden Bamboo (Phyllostachys aurea) (new listing Apr 8, 2013)
Hairy Whitetop (Lepidium appelianum)
Houndstongue (Cynoglossum officinale)
Japanese Barberry (Berberis thunbergii) (new listing Jan 8, 2013)
Japanese Climbing Fern (Lygodium japonicum)
Japanese Honeysuckle (Lonicera japonica)
Japanese Knotweed (Fallopia japonica)
Japanese Spiraea (Spiraea japonica)
Japanese Stilt Grass (Microstegium vimineum)
Johnsongrass (Sorghum halepense)
Kudzu (Pueraria montana var. lobata)
Leafy Spurge (Euphorbia esula)
Medusahead (Taeniatherum caput-medusae)
Mile-A-Minute Weed (Persicaria perfoliata)
Multiflora Rose (Rosa multiflora)
Musk Thistle (Carduus nutans)
Old World Climbing Fern (Lygodium microphyllum)
Oriental Bittersweet (Celastrus orbiculatus)
Princess Tree (Paulownia tomentosa)
Purple Star Thistle (Centaurea calcitrapa)
Quackgrass (Elymus repens)
Russian Knapweed (Rhaponticum repens)
Russian Olive (Elaeagnus angustifolia)
Saltcedar (Tamarix spp.)
St. Johnswort (Hypericum perforatum)
Sacred Bamboo (Nandina domestica) (new listing Apr 8, 2013)
Scotch Broom (Cytisus scoparius)
Scotch Thistle (Onopordum acanthium)
Spotted Knapweed (Centaurea stoebe)
Tree-of-Heaven (Ailanthus altissima)
Tropical Soda Apple (Solanum viarum)
Whitetop (Lepidium draba)
Witchweed (Striga asiatica)
Yellow Star Thistle (Centaurea solstitialis)
Yellow Toadflax (Linaria vulgaris)

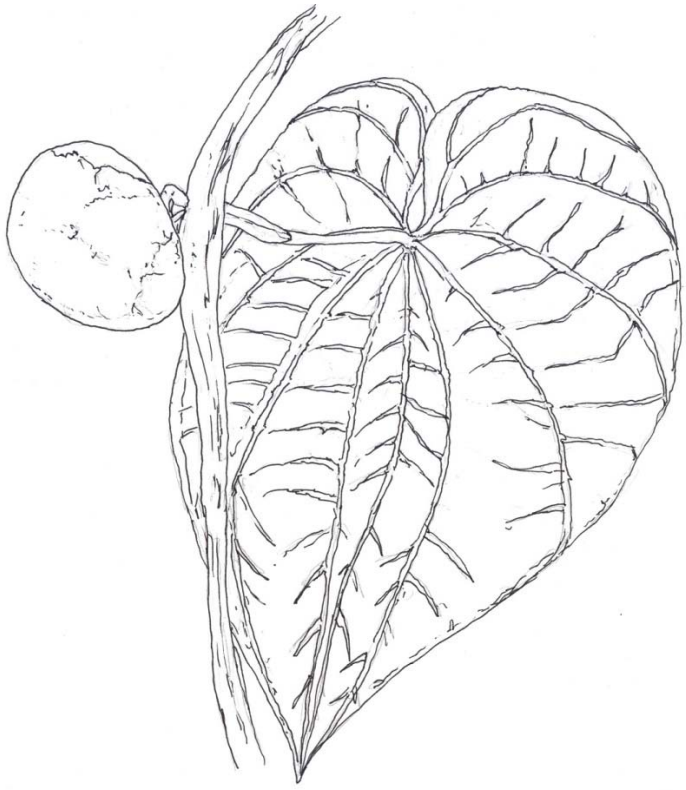
RUSSIAN OLIVE



AUTUMN OLIVE

Federally Listed Invasive Plant Species

Air Potato *Dioscorea bulbifera*



AIR POTATO

Environmental Impact

- Is a non-native, exotic plant (from tropical Asia, Africa) without native insects or diseases to keep its growth in check
- Disrupts native plant communities by forming impenetrable vines on native trees and shading out understory vegetation
- Negatively impacts wildlife dependent on native vegetation for forage, nesting, and cover
- Interferes with ecosystem integrity by threatening biodiversity and ecosystem stability in natural areas
- Increases taxes or fees required to offset costs associated with invasive plant management

Identification

- Perennial, twining vine that reaches well into the canopy of 60 plus foot tall trees
- Alternate, broad, heart-shaped leaves with prominent parallel veins that converge at the basal lobes
- Large numbers of aerial bulbils resembling potatoes form in the leaf axils in late summer
- Plants die back to tubers in winter
- Found from uplands to lowlands

If you are still in doubt, county extension agents are able to assist with the identification of plants.

Control Methods

- Hand pull or disconnect vine-stems to prevent aerial "potato" (bulbil) production; every "potato" is a potential new plant.

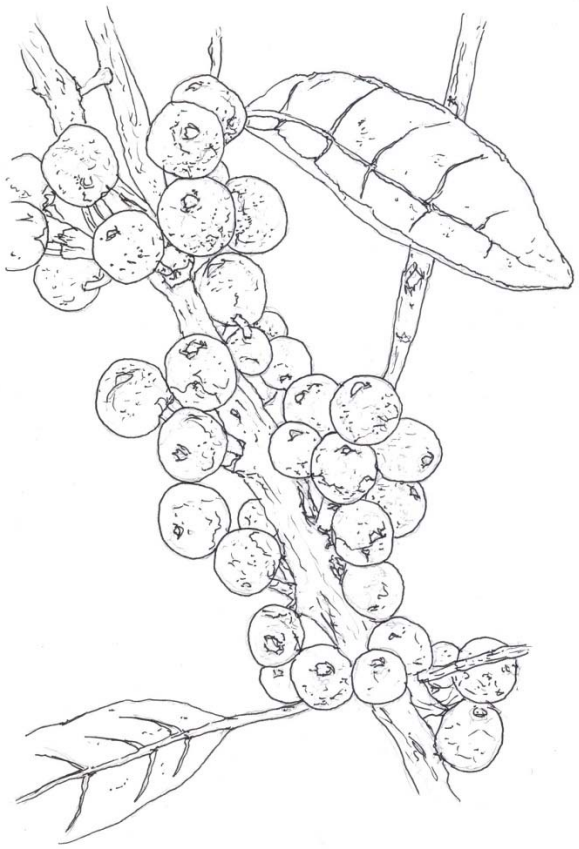
- Dig up underground tubers or germinating "potatoes." Place them in a black plastic bag until they have degraded, or burn them.
- Continue to hand pull sprouting vines to deplete the food reserves of germinated "potatoes."
- If aerial "potatoes" have already formed, hand pick and place them in a black plastic bag until they have degraded, or burn them.
- A 1% triclopyr ester or a 1% glyphosate solution will kill the vegetative part of the plant (foliar application).
- Cut stem treatment with 50% triclopyr amine or 10% triclopyr ester applied within 5 minutes of cutting will be translocated to the underground tuber *.
- Basal bark treatment of 10% triclopyr ester applied to stems emerging from tubers will be translocated to the underground tuber.
- If "potatoes" are present on the vines, a basal bark treatment should be used; herbicide will be translocated to the "potatoes".

Triclopyr products, such as Brush-B-Gon®, and glyphosate products, such as Roundup® and Rodeo® (labeled for aquatic areas), are available in local garden and hardware stores. Always use herbicides according to the label. Remember: The label is the law!

Caution Pesticides used improperly can be injurious to humans, animals, and plants.

- Read, understand, and follow the label.
- Learn and follow all State and local rules.
- Store pesticide safely in original containers.
- Apply pesticides so that they do not endanger humans, or non-target animals or plants.
- If a pesticide is swallowed or gets in the eyes, follow the first-aid treatment given on the label, and get prompt medical attention.
- If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.
- Do not clean spray equipment or dump excess spray material in or near water.
- Dispose of empty pesticide containers properly and promptly.

Autumn Olive *Elaeagnus umbellata* Thunber



AUTUMN OLIVE

Common Names: autumn olive, oleaster
Native Origin: Introduced to the United States from East Asia in the 1830's
Description: Autumn olive is a deciduous shrub or small tree in the Oleaster family (Elaeagnaceae) that grows to approximately 20 feet in height. Leaves are dark green, alternate, oval to lanceolate, and untoothed. The underside is covered with silver-white scales. The small, light yellow flowers are borne along twigs after the leaves have appeared early in the growing season. The small, round, juicy fruits are reddish to pink, dotted with scales, and produced in great quantity. Birds forage on its fruits and contribute to seed dispersal.

Autumn olive is easily confused with a closely related species, Russian olive, which is also an invasive species. Russian olive has elliptic to lanceolate leaves, its branches are usually thorny, and its fruit is yellow, dry and mealy.

Habitat: It grows well in a variety of soils including sandy, loamy, and somewhat clayey textures with a pH range of 4.8-6.5. It has nitrogen-fixing root nodules which allow it to thrive in poor soils. Mature trees tolerate light shade, but produce more fruits in full sun, and seedlings may be shade intolerant. It does not do well on wet sites or in densely forested areas. It is drought tolerant and may invade grasslands and sparse woodlands. Typical habitats are disturbed areas, roadsides, pastures and fields.

Distribution: This species is reported from states shaded on Plants Database map. It is reported invasive in CT, DC, DE, FL, GA, IL, IN, KY, MD, MI, MO, NC, NH, NJ, NY, OH, PA, RI, TN, VA, VT, and WI.

Ecological Impacts: Autumn olive has the potential of becoming one of the most troublesome shrubs in the central and eastern United States. It exhibits prolific fruiting and rapid growth that suppresses native plants. It is widely disseminated by birds and can easily adapt to many sites. Due to its nitrogen-fixing capabilities, it has the capacity to adversely affect the nitrogen cycle of native communities that may depend on infertile soils.

Control and Management:
• **Manual**- Seedlings and sprouts can be hand-pulled when the soil is moist to insure removal of the root system. Note: On larger plants, cutting alone results in thicker, denser growth. Burning during the dormant season also results in vigorous re-sprouting.
• **Chemical**- It can be effectively controlled using any of several readily available general use herbicides such as glyphosate. Foliar application has proven effective in controlling these species. Since glyphosate is a nonselective herbicide it will affect all green vegetation with which it comes into contact. Care should be taken to avoid impacting native plant species. Glyphosate herbicides are recommended because they are biodegradable. Follow label and state requirements.

Triclopyr products, such as Brush-B-Gon®, and glyphosate products, such as Roundup® and Rodeo® (labeled for aquatic areas), are available in local garden and hardware stores. Always use herbicides according to the label. Remember: The label is the law!

Caution Pesticides used improperly can be injurious to humans, animals, and plants.

- Read, understand, and follow the label.
- Learn and follow all State and local rules.
- Store pesticide safely in original containers.
- Apply pesticides so that they do not endanger humans, or non-target animals or plants.
- If a pesticide is swallowed or gets in the eyes, follow the first-aid treatment given on the label, and get prompt medical attention.
- If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.
- Do not clean spray equipment or dump excess spray material in or near water.
- Dispose of empty pesticide containers properly and promptly.

NOTE: When herbicides are used, it is the applicator's legal responsibility to read and follow directions on the product label. Not following label directions, even if they conflict with information provided herein, is a violation of federal law.

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Beach Vitex *Vitex rotundifolia L. f.*

BEACH VITEX

Common names: Beach vitex, chasteberry, roundleaf chastetree, Monk's pepper

Vitex rotundifolia (**beach vitex**) is a species of *Vitex* that is native to seashores throughout the Pacific. Its range includes continents and islands stretching from India east to Hawaii and from Korea south to Australia. This woody perennial plant typically grows approximately 1 m in height. It has a sprawling growth habit and produces runners that root regularly at nodes.

This rooting pattern allows the plant to spread rapidly. At maturity, *V. rotundifolia* produces blue-purple flowers that are borne in clusters and ultimately yield small brown-black fruits. Its leaves are rounded at the tips with green upper surfaces and silver lower surfaces. While the plant is a seashore obligate, it grows over a wide latitude range. It has been used for medicinal purposes throughout its native range.

More recently, it was imported to the eastern United States where it has become a seashore invasive. Control efforts are presently underway to protect the fragile beach dune ecosystem. *Vitex rotundifolia* is a member of the family Lamiaceae and subfamily Viticoideae. The plant was originally described by the son of Carolus Linnaeus, Carl Linnaeus the Younger The original description was published in *Supplementum Plantarum* in 1782. The generic epithet, *Vitex*, is derived from the Latin *viere*, meaning "to bind or twist" in reference to the rope-like stems produced by some species in the genus. The specific epithet, *rotundifolia*, is derived from the Latin *rotundus*, which means "round, spherical", and *folium*, meaning "leaf." This is a reference to the rounded character of the leaves.

Canada Thistle *Cirsium arvense (L.) Scop.*

Canada thistle (*Cirsium arvense*) is an aggressive, creeping perennial weed that infests crops, pastures, rangeland, roadsides and non-crop areas. Generally, infestations start on disturbed ground, including ditch banks, overgrazed pastures, tilled fields or abandoned sites. Canada thistle reduces forage consumption in pastures and rangeland because cattle typically will not graze near infestations. Canada thistle is a creeping perennial that reproduces from vegetative buds in its root system and from seed. It is difficult to control because its extensive root system allows it to recover from control attempts. Combining control methods is the best form of Canada thistle management. Persistence is imperative so the weed is continually stressed, forcing it to exhaust root nutrient stores and eventually die.

Asteraceae (Sunflower family)
Origin: Eurasia
Location: gardens, waste areas, roadsides, cropland, pastures, rangeland, waterways, and native plant communities.

Occurrence: Germination takes place mainly in the spring, but some germination also occurs in the autumn. Autumn seedlings form a rosette and overwinter in that stage. Spring seedlings start emerging when temperatures average 40ºF. In late spring, rosettes produce a flowering stalk, and approximately 2 months after seedling emergence, flower buds develop. Flowering occurs from mid-to-late summer, and seeds mature 8-10 days after flowers open. Shoots are also produced from the roots throughout the season. Aboveground vegetation dies with hard frost.

Description: An upright creeping perennial. Mature leaves are strongly serrated or have deep, irregular lobes with stiff, spiny tips. Stems are occasionally sparsely hairy, grow 1 - 4 feet tall, are branched above, and bear leaves in an alternate arrangement. Leaves are 1 - 6 inches long, 1/4 - 2 inches wide, and clasp the stem with no stalk. Small, faded purple to pink (rarely white) flower heads, which are 1/2 - 3/4 inch in diameter, develop at branch tips, often in clusters of one to five flower heads.

Flower heads give rise to seed heads that contain many 1/8 inch long, golden-brown, single-seeded fruits with fluffy, tan hairs loosely attached to the top of each fruit.

Weedy Characteristics: Canada thistle spreads mainly by producing shoots from aggressive, creeping roots. The root system grows both horizontally and vertically, usually remaining in the top 2 feet of soil, but a portion may penetrate to 20 feet in depth. Horizontal growth can be 13- 20 feet in a single season. The plant can form dense colonies, and one plant might spread to cover a 115 foot diameter area. Canada thistle is quite adaptable and its extensive root system makes it possible for the plant to survive in almost any soil. The plant will tolerate saline soil and dry or wet (but not saturated) conditions. Plants can produce about 1500 seeds each, which are dispersed via wind, water, birds that consume them, in crop seed and hay, on machinery, and on human and animal feet. Seeds can remain viable in the soil for up to 20 years. Canada thistle may secrete chemicals that inhibit the growth of nearby plants.

Control: Canada thistle seeds and seedlings require light, open environments and readily establish on bare ground. Maintaining healthy, competitive desirable vegetation can help prevent Canada thistle colonization. Thick mulch will discourage germination of seeds. Digging or hoeing young seedlings within 2 weeks of emergence is highly effective, since plants do not develop perennial root characteristics until the third week. Mature plants are much more difficult to manage. Seed production can be prevented by hand-cutting or mowing tops at least three times in the season. However, one or two seasons after above ground parts are destroyed, new shoots can still generate from the extensive root system. Any flower heads that have been open much more than 1 week are capable of setting seed, even after being cut from the parent plant. These should be removed completely. Digging, hoeing, and tilling mature plants fragments the extensive root system, stimulating new growth. Even very small root fragments can produce new plants within about 2 weeks. Nevertheless, consistent use of these methods for at least 2 years can exhaust Canada thistle root reserves enough to achieve some control. For current chemical or biological methods, consult your local state or county weed specialist.

Herbicides such as glyphosate can be painted on thistle leaves. Repeat applications will be needed. Herbicides such as triclopyr + clopyralid or 2,4-D combinations can be sprayed on thistle foliage; repeat applications may be needed at 6 week intervals. The most effective times for herbicide applications are spring, just after the green shoots appear, or in August/September. Always read the label before applying any pesticide.

General Facts: Young Canada thistle shoots and roots have been eaten by some native peoples, and the plant has been used for several traditional medicinal purposes, including as a mouthwash. Bees use Canada thistle as a source of nectar and pollen, and some wildlife will feed on it, but most domestic livestock will not eat it, and will not even graze near it for its spines. Its presence can cause crop yield loss and reduce recreational land use, it can interfere with harvesting operations, and its seed can contaminate small grain stocks. The plant can also serve as an alternate host for insects and other pests that cause crop disease. Canada thistle is considered noxious or invasive in every U.S. state, and also in six Canadian provinces.

Other Common Names: Californian thistle, creeping thistle, field thistle

Chemical Control

Aminocyclopyrachlor + chlorsulfuron (Perspective)

Rate 1.8 to 3.2 oz/A aminocyclopyrachlor + 0.7 to 1.3 oz/A chlorsulfuron (4.5 to 8 oz/A of product)
Time Apply to actively growing plants in spring.
Remarks Adjuvants can be used; these include methylated seed oils 0.5 to 1% v/v, nonionic surfactants at 0.25 to 1% v/v, and crop oil concentrates at 1%v/v. Can be applied using an invert emulsion rather than water.
Caution Even low rates can kill nontarget tree and shrub species, so avoid application within a distance equal to the tree height of the sensitive species. Do not allow spray to drift off target. Can injure several grass species including bromes, as well as basin wildrye.
Site of action Group 4 synthetic auxin (aminocyclopyrachlor) Group 2: ALS inhibitor (chlorsulfuron)
Chemical family Phenoxy acetic acid (aminocyclopyrachlor); sulfonylurea (chlorsulfuron)

Aminopyralid (Milestone)

Rate 1.25 to 1.75 oz ae/A (5 to 7 fl oz/A Milestone)
Time Apply in the spring to plants in the prebud stage of growth or in the fall to plant regrowth.
Remarks A nonionic surfactant at 1 to 2 quarts per 100 gal of spray enhances control under adverse environmental conditions.
Caution Do not allow drift to desirable vegetation. Many forbs (desirable broadleaf plants) can be seriously injured or killed. Do not exceed 7 fl oz/A Milestone per year.
Site of action Group 4: synthetic auxin
Chemical family Pyridine

Chlorsulfuron (Telar)

Rate 1.125 oz ai/A (1.5 oz/A)
Time Apply postemergence. For best results, apply to thistles in the bud-bloom stage or to fall rosettes.
Remarks Do not apply to frozen ground. Constantly agitate while mixing in spray solution. Add 0.25% v/v nonionic surfactant to the spray mixture.
Caution Avoid contact with sensitive crops. For non-cropland use only. Chlorsulfuron can persist in soil; if land is to return to cropland, allow sufficient time for product to dissipate. Powdery, dry soils and light, sandy soils should not be treated if rain is not likely after treatment.
Site of action Group 2: acetolactate synthase (ALS) inhibitor
Chemical family Sulfonylurea

Clopyralid + 2,4-D amine (Curtail) or clopyralid (Stinger or Transline)

Rate Consult labels. Rate depends on use site.
Time Apply to actively growing thistle after most basal leaves emerge but before bud stage.
Remarks Lower rate for in-crop cereal grain application, higher rate for fallow, postharvest, non-crop, and Conservation Reserve Program (CRP) applications. See label for specifics. CRP applications are for established grass only. For best results, wait at least 20 days after application before disturbing treated areas (cultivation, mowing, fertilization with shank-type applicators) to allow thorough translocation. Apply in enough total spray volume to ensure good coverage.
Caution Consult label for crop rotation restrictions before using these products. Several crops may be injured up to 4 years after application. Do not transfer livestock from treated areas to sensitive broadleaf crop areas without first grazing 7 days on untreated pasture.
Site of action (both) Group 4: synthetic auxin
Chemical family (clopyralid) pyridine; (2,4-D) phenoxy acetic acid

Dicamba (Banvel, Rifle, or Clarity)

Rate 2 lb ae/A. Spot treatment: use mixtures of 2 to 4 lb ae dicamba per 100 gal of water.
Time May be applied any time during the growing season.
Remarks Higher rates may be required in high-rain areas. Soil residues are normally for one winter in western Oregon. Apply dicamba to growing thistles; uptake is through both foliage and root system. May mix with glyphosate to apply in fall.
Caution Avoid drift to sensitive crops. Dicamba will damage or kill clovers in pastures.
Site of action Group 4: synthetic auxin
Chemical family Benzoic acid

Diflufenzopyr + dicamba (Overdrive)

Rate 0.26 to 0.35 lb ae/A (6 to 8 oz/A)
Time Apply in spring to the rosettes.
Remarks Add a surfactant, either nonionic or methylated seed oil, to the spray mix.
Caution Avoid drift to sensitive crops. Will kill legumes.
Site of action (diflufenzopyr) Group 19: inhibits indole acetic acid transport; (dicamba) Group 4: synthetic auxin
Chemical family (diflufenzopyr) semicarbazone; (dicamba) benzoic acid

Glyphosate

Rate Broadcast: 1.5 to 2.25 lb ae/A; wiper: 10 to 33% solution. Hand-held and high-volume equipment: 2% solution

Time Apply when thistles are actively growing but past the bud growth stage. Fall applications must be before the first killing frost. Thistles that were mowed or tilled and have rosettes at least 6 inches wide in late summer or fall can be suppressed with 0.75 lb ae/A glyphosate plus 0.5 to 1% nonionic surfactant applied in 3 to 10 gal/A water.

Remarks Wait 3 days for maximum root translocation of glyphosate before tillage.

Caution Glyphosate controls grasses as well as other vegetation in treated areas.

Site of action Group 9: inhibits EPSP synthase

Chemical family None generally accepted

Picloram (Tordon)

Rate In broadcast or boom sprayers, apply 1 lb ae/A. Mixtures normally used for spot treatments include 1 lb ae per 100 gal of water.

Time Control is best if applied to actively growing thistle after most leaves emerge but before bud stage.

Remarks Picloram is both a foliar and soil active herbicide. It will not kill perennial grasses when used according to the label.

Caution Most formulations are restricted-use herbicides. Do not contaminate water. Potatoes, beans, and many other broadleaf crops are very sensitive to picloram. Do not use in diversified cropping areas. Do not graze dairy animals on treated areas within 2 weeks after application. For rates exceeding 0.5 lb ae/A (1 quart/A), apply only as a spot treatment not to exceed 25% of a landowner's acreage in any particular watershed in a single season.

Site of action Group 4: synthetic auxin

Chemical family Pyridine

Triclopyr + clopyralid (Redeem R&P)

Rate 2.5 to 4 pints/A

Time Apply from rosette to bud stage to actively growing thistle.

Remarks Add a nonionic surfactant at surfactant manufacturer's recommended rate. Apply in at least 10 gal/A water by ground.

Caution Do not exceed 4 pints/A per year. Do not allow drift to desirable vegetation. Note label restrictions on overseeding or reseeding.

Site of action (both) Group 4: synthetic auxin

Chemical family (both) pyridine

NOTE: When herbicides are used, it is the applicator’s legal responsibility to read and follow directions on the product label. Not following label directions, even if they conflict with information provided herein, is a violation of federal law.

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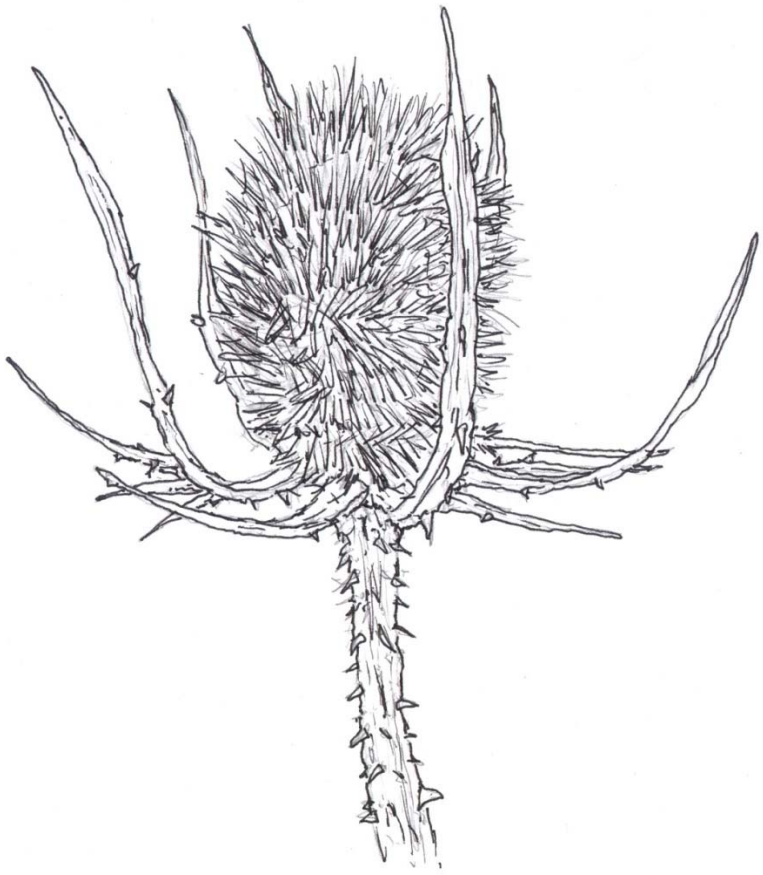
Common Teasle *Dipsacus fullonum*



COMMON TEASEL

Dipsacus is a genus of flowering plant in the family Caprifoliaceae. The members of this genus are known as **teasel**, **teazel** or **teazle**. The genus includes about 15 species of tall herbaceous biennial plants (rarely short-lived perennial plants) growing to 1–2.5 metres (3.3–8.2 ft) tall. Dipsacus are native to Europe, Asia and northern Africa.

The genus name is derived from the word for thirst and refers to the cup-like formation made where sessile leaves merge at the stem. Rain water can collect in this receptacle; this may perform the function of preventing sap-sucking insects such as aphids from climbing the stem. A recent experiment has shown that adding dead insects to these cups increases the seedset of teasels (but not their height), implying partial carnivory. The leaf shape is lanceolate, 20–40 centimetres (7.9–15.7 in) long and 3–6 centimetres (1.2–2.4 in) broad, with a row of small spines on the underside of the midrib.

Teasels are easily identified with their prickly stem and leaves, and the inflorescence of purple, dark pink or lavender flowers that form a head on the end of the stem(s). The inflorescence is ovoid, 4–10 centimetres (1.6–3.9 in) long and 3–5 centimetres (1.2–2.0 in) broad, with a basal whorl of spiny bracts.

The first flowers begin opening in a belt around the middle of the spherical or oval flowerhead, and then open sequentially toward the top and bottom, forming two narrow belts as the flowering progresses. The dried head persists afterwards, with the small (4–6 millimetres (0.16–0.24 in)) seeds maturing in mid autumn.

Teasel is also considered an invasive species in the United States. It is known to form a monoculture, capable of crowding out all native plant species, and therefore is discouraged and/or eliminated within restored open lands and other conservation areas.
Selected *Dipsacus* species:

- *Dipsacus ferox* - Spiny Teasel
- *Dipsacus fullonum* - Wild Teasel, Common Teasel, Fuller's Teasel
- *Dipsacus japonica* - Japanese Teasel, Chinese Teasel
- *Dipsacus laciniatus* - Cut-leaved Teasel
- *Dipsacus pilosus* - Small Teasel
- *Dipsacus sativus* - Fuller's Teasel (cultivated form)
- *Dipsacus strigosus* - Slim Teasel

Dalmatian toadflax *Linaria dalmatica*

DALMATION TOADFLAX

Dalmatian toadflax, a native of the Mediterranean region, was introduced to the Americas in 1900 as an ornamental. The pioneers loved this plant because of its lavish, bright yellow flowers and its durability. Toadflax was easy to establish and homesteaders liberally landscaped their properties with this drought resistant plant, continually spreading it in their migration to the Western frontier. Also, burial sites were often adorned with toadflax to give everlasting beauty and tranquility. Their legacy has prevailed, proving to be notorious in nature.

Always follow label instructions and take steps to avoid exposure. If any exposures occur, be sure to follow the First Aid instructions on the product label carefully. For additional treatment advice, contact the Poison Control Center at 1-800-222-1222. If you wish to report a pesticide problem, please call 1-800-858-7378.

Chemical Control Options
chlorsulfuron (Telar)
Idaho and Washington only

Rate 1.5 to 2.25 oz ai/A (2 to 3 oz/A Telar)
Time Apply to actively growing yellow toadflax in the bud to bloom stage.
Remarks Suppresses yellow toadflax. Selective to grasses. Use a penetrating surfactant. Spray to wet.
Caution Do not let spray drift onto sensitive crops. Apply only to non-cropland.
Site of action Group 2: acetolactate synthase (ALS) inhibitor
Chemical family Sulfonylurea

Dicamba (Banvel, Rifle, or Clarity)

Rate 4 to 6 lb ae/A
Time Apply in early spring before toadflax reaches bloom stage.
Remarks Repeated applications may be necessary for complete control.
Caution Avoid drift to sensitive crops. Dicamba severely injures or kills most broadleaf plants.
Site of action Group 4: synthetic auxin
Chemical family Benzoic acid

Imazapic (Plateau)

Rate 0.188 lb ai/A
Time Apply in the fall when top 25% of plant is necrotic, usually after a hard frost.
Remarks Add 1 quart/A methylated seed oil to the spray mix.
Caution Before using, note crop rotation restrictions.
Site of action Group 2: acetolactate synthase (ALS) inhibitor
Chemical family Imidazolinone

Picloram (Tordon)

Rate 1 lb ae/A
Time Apply to actively growing toadflax in spring before full bloom or in late summer or fall.
Remarks A selective treatment that will not damage perennial grasses at the suggested rate.
Caution Most formulations are restricted-use herbicides. Do not contaminate water. Do not use in diversified crop areas. Potatoes, beans, and most other broadleaf crops are sensitive to picloram. This rate for spot treatment only.
Site of action Group 4: synthetic auxin
Chemical family Pyridine

Picloram (Tordon 22K) + 2,4-D

Rate 0.5 lb ae/A picloram + 1.5 lb ae/A 2,4-D
Time In spring before full bloom.
Remarks May require annual treatment for 2 to 3 years. This rate of Tordon 22K may be broadcast.
Caution Tordon is a restricted-use herbicide. See label for grazing restrictions. If rate exceeds 0.5 lb ae/A (1 quart/A), apply only as a spot treatment not to exceed 25% of a landowner's acreage in any particular watershed in a single season. Avoid drift to sensitive crops. Do not contaminate water. Potatoes, beans, and many other broadleaf crops are sensitive to these herbicides. Do not use picloram in diversified crop areas.
Site of action (both) Group 4: synthetic auxin
Chemical family (picloram) pyridine; (2,4-D) phenoxy acetic acid

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Diffuse Knapweed *Centaurea diffusa*

DIFFUSE KNAPWEED

Diffuse knapweed (*Centaurea diffusa*) is a short-lived perennial, a biennial, or occasionally an annual. It reproduces and spreads from seed. The plant develops a single shoot (stem), 1 to 2 feet tall or more, that is branched toward the top. Grazed plants may produce multiple stems. Rosette and lower shoot leaves are deeply divided and covered with short hairs. Leaves become smaller toward the top of the shoot and have smooth margins.

Many solitary flowering heads occur on shoot tips. They are about 1/8 inch in diameter and 1/2 to 2/3 inch long. Flowers usually are white but may be purplish (Figure 4). Involucre bracts are divided like teeth on a comb and tipped with a slender spine that makes them sharp to the touch. Sometimes the bracts are dark-tipped or spotted like spotted knapweed. The long terminal spine differentiates diffuse from spotted knapweed.

Spotted knapweed (*Centaurea stoebe*; a.k.a., *C. biersteinii* and *C. maculosa*) looks like diffuse knapweed with some notable exceptions. Spotted knapweed is a shortlived, non-creeping perennial that reproduces from seed (primary means of spread) and forms a new shoot each year from a taproot.

The weed produces one or more shoots that are branched and 1 to 3 feet tall. Rosette leaves can be 6 inches long and deeply lobed. Leaves are similar to diffuse knapweed. Lavender to purple flowers are solitary on shoot tips and about the same size as diffuse knapweed flowers. Involucre bracts are stiff and black-tipped. The tip and upper bract margin have a soft, spinelike fringe and the center spine is shorter than others.

Phenology, Biology and Occurrence

Diffuse knapweed seeds germinate in spring or fall or anytime during the growing season following a disturbance, if adequate soil moisture is present. Seedlings develop into rosettes and diffuse knapweed remains as a rosette until it grows to a critical size, then it bolts, flowers, and sets seed. It may take from one to several years for diffuse knapweed to reach the critical size necessary to reproduce by seed. Diffuse knapweed plants break off at the soil surface and become tumbleweeds over winter and disperse their seeds in the process. It often gets caught in pasture fences, which can lead to damaged fences.

Management
Diffuse and spotted knapweed can be managed similarly. They are readily controlled with herbicides. However, the weeds will reinvade unless cultural techniques are used.

Chemical control. Research conducted at Colorado State University indicates that Tordon 22K (picloram), Milestone (aminopyralid), Transline (clopyralid), Curtail (clopyralid + 2,4-D), or Banvel/Vanquish/Clarity (dicamba) control diffuse knapweed. Tank mixes of Banvel/Vanquish/Clarity plus 2,4-D at 1 pt + 2 pt/A or Banvel/Vanquish/Clarity control diffuse knapweed. Refer to Table 1 for rate and timing recommendations.

Table 1. Herbicide used to control diffuse and spotted knapweed.

Herbicide	Rate (Product/A)	Application timing	Comments
Tordon	1 to 2 pints	Spring at rosette to mid-bolt growth stages; or fall	Use higher rates for older or dense stands
Milestone	5 to 7 fl oz	Spring at rosette to bolting growth stages; or fall	Use higher rate for older or dense stands; Milestone may be used to edge ponds or streams
Transline	0.67 to 1.33 pints	Spring after all shoots have emerged, rosette to early bud growth stages; or fall	Use higher rate for older or dense stands
Curtail	2 to 3 quarts	Spring after all shoots have emerged, rosette to early bud growth stages; or fall	User higher rate for older or dense stands
Banvel, Vanquish, or Clarity (dicamba)	1 to 2 pints	Spring rosette growth stage; or in fall	Use higher rate for older or dense stands

Tank mixes of Banvel/Vanquish/Clarity plus 2,4-D at 1 pint + 2 pints/A or Banvel/Vanquish/Clarity plus Tordon 22K at 1 to 2 pints + 0.5 to 1 pint/A or Tordon plus 2,4-D at 0.75 pint + 2 pints/A all control diffuse knapweed. These tank-mixes may save money and reduce grass injury resulting from higher use rates of a single herbicide. Adding 2,4-D to a tank mix, however, with very selective herbicides such as Tordon, Milestone, or Transline, broadens the spectrum of activity and may result in increased injury to desirable native forbs (broadleaf plants) and shrubs, which are important components of the plant community to resist re-invasion by weedy forbs (broadleaf weeds like diffuse and spotted knapweed).

Spotted knapweed and diffuse knapweed generally occupy the same areas in Colorado, so the same herbicide treatments can be applied. Weed scientists at Montana State University indicate that Tordon controls spotted knapweed for two to three years, but the weed will reinvade the area unless other management techniques are used. Milestone also is very effective to control spotted knapweed and Transline, Curtail, and Banvel/Vanquish/Clarity also control spotted knapweed and these herbicides too should be coupled with cultural control.

Cultural control. If desirable plant (grasses and forbs) competition is evident in diffuse or spotted knapweed stands, judicious herbicide application that does not injure desirable plants (especially grasses) may allow them to compete effectively with the weeds. Irrigation (where possible) may help stimulate grass competition in these cases. However, infested rangeland or pastures often are degraded, allowing knapweed invasion, and herbicides alone usually will not restore the land to a productive state. Seeding suitable perennial grasses, forbs, and shrubs is necessary to prevent weed reinvasion.

Biological control. Many insects are being evaluated for biological control of diffuse and spotted knapweeds. Researchers at Montana State University believe it will take a complex of insects (perhaps 12) to reduce diffuse and spotted knapweed populations.

Garlic Mustard *Alliaria petiolata*

GARLIC MUSTARD

Nature: A biennial herb, in small to extensive colonies under forest canopies, with basal rosettes of leaves in the first year (remaining green during winter) becoming 2-4 ft. tall in the second year. Leaves broadly arrow-point shaped with wavy margins and flowers in terminal clusters having four white petals. All plant parts have an odor of garlic. Prolific seed producer and seeds lay dormant for 2-6 years before germination, with germination only in spring. Seeds spread by humans, animals and transported in fill-dirt.

Origin: Introduced from Europe in the 1800's.
Uses: None now, originally introduced as a medicinal herb.
Family: Mustard Family (Brassicaceae)
Other Names: Alliaria alliaria, Alliaria officinalis, Erysimum alliaria, Sisymbrium alliaria, Sisymbrium officinalis, garlic root, garlicwort, hedge garlic, Jack-by-the-hedge, poorman's-mustard, sauce-alone.
Origin and Distribution: Garlic mustard was brought to North America from Europe, most likely as a medicinal herb or green vegetable. It was first described in the U.S. on Long Island, New York in 1868. Since then, populations of garlic mustard have been reported in 30 states, mostly in the Northeast and Midwest. Garlic mustard is distributed in moist woods and swampy areas and along forest edges and stream banks. It also invades disturbed areas such as roadsides and railways and is becoming a troublesome weed in reduced tillage. This species is usually found in shaded conditions, but is becoming more and more common in full sun. It prefers to grow in moist, rich soil, but can tolerate drier sites.

Plant Description: Garlic mustard is a biennial that forms a rosette the first spring and an upright stem with small white flowers the second spring. It is characterized by triangular, coarsely toothed leaves and a slender taproot with a distinct S-curve just below the root crown. Young leaves give off a strong garlic odor when crushed, but the odor fades with leaf age and is nearly gone by fall. Garlic mustard reproduces only by seeds.
Root system - Garlic mustard has a slender, white taproot that curves into a distinctive S-shape just below the crown.
Seedlings & Shoots - Young plants form rosettes of dark green, kidney-shaped leaves that have scalloped edges and long hairy leaf stalks (petioles).
Stems - Stems are usually smooth (sometimes with sparse hairs) and unbranched. They can grow from 1/2 to 3 1/2 feet tall. One plant usually produces 1 to 2 stems (sometimes more).
Leaves - Rosette leaves are dark green, kidney- to heart- to egg-shaped, shallowly toothed, and 2 to 4 inches in diameter. Stem leaves are alternate (1 per node), coarsely toothed, and triangular to heart-shaped. Stem leaves are largest (2 to 4 inches wide and long) on the lower portion of the stem, and become smaller toward the top of the stem. Both rosette and stem leaves have long, hairy leaf stalks (petioles) (1/2 to 2 inches long).
Flowers - Flowers are borne in clusters at the tops of stems. Each flower consists of 4 white petals that are about 1/4 inch long and form the shape of a cross.

Fruits & Seeds - The fruit is a long, narrow pod (1 to 2 inches long). Each pod contains an average of 16 small, black, oblong seeds (1/4 inch long, 1/8 inch in diameter).

Similar Species: The rosettes of other species including violets (Viola spp.) and white avens (Geum canadense) may be confused with young rosettes of garlic mustard, but only garlic mustard gives off a strong garlic odor when crushed. The flowering stage of garlic mustard may be confused with dame's rocket (Hesperis matronalis), also a spring blooming mustard that forms upright flowering stems and white flowers (sometimes pink). However, the flowers of dame's rocket are much larger and showier than those of garlic mustard, its leaves are lance-shaped and crushed foliage does have a garlic odor.

Biology: Seeds of garlic mustard germinate from late February to mid-May, and form leafy rosettes that persist through the summer and winter. Surviving rosettes produce erect flowering stems the following March, and flowers appear from April to May. Seeds begin to ripen in mid-June and are shed continually through September. Only a few seeds germinate the first spring. Most seeds germinate the second spring after their production. Remaining seeds can stay viable in the seedbank for 5 to 6 years. The number of seed pods produced per plant varies greatly. The smallest plants may produce only 1 or 2 pods, while large plants can produce 150 pods or more. Each pod contains an average of 16 seeds. In dense patches of garlic mustard, over 20,000 seeds per square foot can be produced annually.

This weed is invasive and very difficult to control once established. It tends to form dense stands that crowd out herbaceous native flora. As a result, invasion of garlic mustard into forests tends to decrease the number of native spring species. Garlic mustard can be controlled by preventing new seed production for several years until the seedbank is depleted. Various methods can be used to prevent seed formation, including cutting plants at ground level just before or during flowering, hand pulling, burning, or spot application of herbicides (optimally in early spring or fall). When hand pulling, a significant portion of the root crown must be removed or else plants can resprout. However, the best management strategy is to prevent establishment.

Toxicity: None known.

Herbicide Control: Apply a glyphosate herbicide as a 2% solution in water (8 ounces in a 3-gal. sprayer) with a surfactant (or without a surfactant when near surface waters) to thoroughly wet all foliage in April through June (during flowering) to control two generations. Pulling plants before seed formation is recommended where herbicides cannot be used, while repeated annual prescribed burns in fall or early spring will control this plant.

Mechanical Weed Control: Mechanical weed control involves the physical destruction of a weed. Techniques involve hand pulling and hand hoeing which are practical for small infestations. Mowing is often used; but by far, the most common practice of mechanical control includes tillage. Advantages of tillage include:
• Elimination of weed debris
• Control of annual weeds
• Suppression of perennial weeds
• Tillage methods include plowing, rototilling, disking, and harrowing. Weed control implements include sweeps, rolling cultivators, finger weeders, push hoes, rotary hoes, etc.

Related Information:
- ✓ The genus name of garlic mustard (Alliaria) is partly derived from the genus name for garlic (Allium) because of garlic mustard's strong garlic-like odor.
- ✓ Garlic mustard is also known as 'sauce-alone' because it was customary to use the plant in sauces and salads.
- ✓ Garlic mustard is higher in vitamins A and C than many commercially available fruits and vegetables.

Golden bamboo *Phyllostachys aurea*

Common Names: golden bamboo, fishpole bamboo, running bamboo
Native Origin: China; and cultivated in Japan for centuries.
Description: Golden bamboo culms can reach a height of 8 to 10 meters. The alternate, grass-like, leaves are lanceolate; 1.5 dm long and 1 to 2 cm wide and often in fan clusters. The edges of the leaves may be rough or smooth without lobes. Golden bamboo flowers infrequently, may not flower for several decades and in many cases will preclude the death of the plant. Spikelets are solitary and 8 to 12 flowered. Stems are solid jointed canes 1 to 6 inches (2.5 to 15 cm) in diameter that are hollow between joints and golden to green to black. Stems branch wiry and grass-like from joints. Lower shoots and branches with loose papery sheaths cover the ground when shed. Roots primarily spread by rhizomes. Shoots develop in the spring with initiation primarily controlled by temperature. The culms grow from side shoots at alternate nodes of the rhizome.

Habitat: Golden bamboo thrives in full sun in all but the hottest climates where it requires some shade. It will grow in sparsely wooded secondary forests. Vigorous growth and spread is seen in moist, deep loamy soils. In habitats less than ideal, it will continue to grow and spread at a diminished rate.

Distribution: This species is reported from states shaded on Plants Database map. It is reported invasive in GA, MD, PA, VA, and WV.
Ecological Impacts: It is common around old home-sites and has escaped. It colonized by rhizomes with infestations rapidly expanding after disturbance.

Control and Management:
• **Manual**- Cutting/Mowing**:** This method can be used on small infestations or where herbicides cannot be used. Cut plants as close to the ground as possible. Repeat several times throughout the growing season as plants re-sprout. Monitoring and retreatment will be necessary for several growing seasons until the energy reserves in the rhizomes are exhausted.
• **Chemical**- It can be effectively controlled using any of several readily available general use herbicides such as glyphosate. Foliar Spray Method**:** This method should be considered for large areas of bamboo

where risk to non-target species is minimal. Air temperature should be above 65°F to ensure absorption of herbicides. Follow label and state requirements.

References: www.forestimages.org, http://plants.usda.gov, www.nps.gov/plants/alien,
Invasive Plants of the Eastern United States www.invasive.org, Miller, James H., Nonnative Invasive Plants of Southern Forests, A Field Guide for Identification and Control. USDS SRS-62, p. 56-57

USE PESTICIDES WISELY: ALWAYS READ THE ENTIRE PESTICIDE LABEL CAREFULLY, FOLLOW ALL MIXING AND APPLICATION INSTRUCTIONS AND WEAR ALL RECOMMENDED PERSONAL PROTECTIVE GEAR AND CLOTHING. CONTACT YOUR STATE DEPARTMENT OF AGRICULTURE FOR ANY ADDITIONAL PESTICIDE USE REQUIREMENTS, RESTRICTIONS OR RECOMMENDATIONS.

NOTICE: MENTION OF PESTICIDE PRODUCTS IN THIS COURSE DOES NOT CONSTITUTE ENDORSEMENT OF ANY MATERIAL.

Houndstongue (Cynoglossum officinale)

HOUNDSTONGUE

Family: *Boraginaceae* (Borage)
Other Names: hound's tongue, dog bur, gypsy flower
USDA Code: CYOF

Identification
Growth form: Biennial or short-lived perennial forb.
Flower: Flowers are reddish-purple, with five petals, arranged in panicles in the upper leaf axils.
Seeds/Fruit: The fruit is composed of four prickly nutlets each about 1/3 inch long (Whitson et al*.* 1996).
Leaves: Leaves are alternate, 1-12 inches long, 1-3 inches wide, rough, hairy, and lacking teeth or lobes (Whitson et al*.* 1996). Leaves often appear dusty and insect-ridden. Basal leaves are elliptical to oblanceolate and tapered at the base.
Stems: Houndstongue produces a single flowering stem. The stem is erect, stout, heavy, 1.5 to 3 feet high and usually branched above.
Roots: Houndstongue has a thick, black, woody taproot.
Seedling: Houndstongue forms a rosette the first year of its life cycle.

Similar Species
Exotics: Rosettes may resemble burdock.
Natives: If not flowering, could be mistaken for members of the *Hackelia* or *Lappula* genus (stickseeds).

Impacts
Agricultural: Houndstongue contains toxic alkaloids that stop liver cells from reproducing. Therefore, houndstongue reduces livestock and wildlife forage and grazing animals should be kept away from houndstongue infested areas. Animals may live six or more months after eating a lethal dose of houndstongue. Sheep are more resistant to houndstongue poisoning that cattle or horses. The burs may reduce the value of wool.
Ecological: Houndstongue is an early sucessional species on recently disturbed sites.
Human: Due to its toxicity to grazing animals, houndstongue should not be eaten by humans.

Keys to Identification:
• Five-petaled reddish-purple flowers in panicles.
• Prickly nutlets are distinctive.

Habitat and Distribution
General requirements: Houndstongue prefers areas with more than 10% bare ground (Butterfield et al. 1996), and is common on gravelly, alkaline soils (Stubbendieck et al. 1995).
Distribution: Houndstongue is found over much of North America. It grows on rangeland, pastures, abandoned cropland, roadsides, and waste places (Butterfield et al. 1996). Houndstongue is found on rangeland, pastures, and roadsides throughout Colorado up to about 9000 feet.
Historical: Houndstongue is a native of Eurasia that was introduced to North America as a contaminant in agricultural seed.

Biology/Ecology
Life cycle: Houndstongue is a biennial that produces a rosette the first year. During the second year a flowering stem bolts and produces fruit.
Mode of reproduction: Reproduces solely by seed.
Seed production: Mature plants can produce up to 2,000 seeds (Butterfield et al. 1996).
Seed bank: Seeds remaining on the parent plant may remain viable for 2-3 years. Buried seed rarely survive more than one year (Butterfield et al. 1996).
Dispersal: Seeds stick to clothing and animals and have the ability to be spread great distances.
Hybridization: No information available.

Control
Biocontrol: None known.
Mechanical: Mowing second year plants during flowering but before seed maturation reduces seed production and may kill the plant.
Fire: No information available.
Herbicides: Picloram at 0.25-0.5 lb., 2,4-D, or dicamba at 1.0 lb., or metsulfuron at 0.6 oz. ai/acre applied in spring provides control of houndstongue. Spring treatments with picloram, dicamba, or metsulfuron are more effective than fall treatments (Sebastian and Beck 1995). Chlorsulfuron applied 0.5 lb. ai/ac gave complete control when applied any time beginning with the rosette stage until the bolted plant had attained 10 inches in height (Butterfield et al. 1996).

Cultural/Preventive: Maintaining a healthy population of native perennials the best way to prevent the establishment and spread of houndstongue.

Integrated Management Summary
Houndstongue is poor competitor with native perennials and requires disturbed or bare areas to establish. Once established, houndstongue quickly forms dense monocultures. Treat first year plants with herbicides. Mow bolted plants to eliminate seed production. Repeat this process for several years to exhaust the seed bank. It is imperative to establish a healthy population of native perennials on treated areas to prevent the re-establishment of houndstongue or other noxious weeds.

Keys to Control:
• Eliminate seed production.
• Re-seed controlled areas with desirable species.

Japanese Barberry *Berberis thunbergii* DC.

JAPANESE BARBERRY

Native Range: Japan
Description: Japanese barberry is a compact, spiny, deciduous shrub in the barberry family *Berberidaceae*) that commonly grows from 2 to 3 feet tall (although it can grow up to six feet in height). Roots are shallow but tough. The smooth-edged leaves range from oval to spoon-shaped and are clustered in tight bunches close to the branches. The single spines bear small leaves in their axils. Yellow flowers bloom in May, are about one third of an inch wide, and are solitary or in small clusters of 2-4 blossoms. The bright-red fruits mature in mid-summer and hang from the bush during autumn and into winter. The berries are small, oblong, and found singly or in clusters. The plant regenerates by seed and creeping roots. Birds and rabbits are known to eat the seeds and distribute the species. Branches root freely when they touch the ground; thus allowing single plants to become quite large.

Habitat: Japanese barberry prefers well-drained soils, although it has been found in wet, calcareous situations, (specifically in a black ash swamp). It is typically found in locations of partial sunlight such as woodland's edge; it can survive well under the shade of an oak canopy. It is also found along roadsides, fences, old fields, forest edges, and open woods. Japanese barberry can be found invading oak woodlands and oak savannas; it is widespread in Wisconsin woodlands south of the tension zone.

A related non-native species, *B. vulgaris*, was widely planted for similar purposes, but has been exterminated because it is the alternate host of black rust, a disease that affects wheat crops. Japanese barberry competes poorly with grasses and may succumb to drought conditions.

Distribution: This species is reported from states shaded on the Plants Database map. It is reported invasive in CT, DC, DE, IN, KY, MA, MD, ME, MO, NC, NH, NJ, NY, OH, PA, RI, TN, VA, VT, WI, and WV.

Environmental Impact: It often escapes cultivation. Plants shade out other understory species. Recent research studies in New Jersey indicted that Japanese barberry changes the soil chemistry in environment it inhabits.

Control and Management:

• **Manual-** Mechanical removal of the plant is recommended in early spring because barberry is one of the first shrubs to leaf out, thereby making identification easier. Cutting, pulling or digging are effective in areas where there are only a few plants. A hoe, weed wrench, or mattock should be used to uproot the bush and all connected roots. Thick gloves are recommended for protection from the shrub's spines. Japanese barberry may be relatively easy to control in fire-adapted communities. Fire is thought to kill these plants and prevent future establishment.

• **Chemical-** Triclopyr has been used as a cut-stump treatment with success. Other herbicides labeled for brush control, such as glyphosate, may prove to be effective. Care in application is essential because glyphosate is a non-selective herbicide that can kill native species as well. Herbicides are suggested only for plants that are difficult to remove mechanically.

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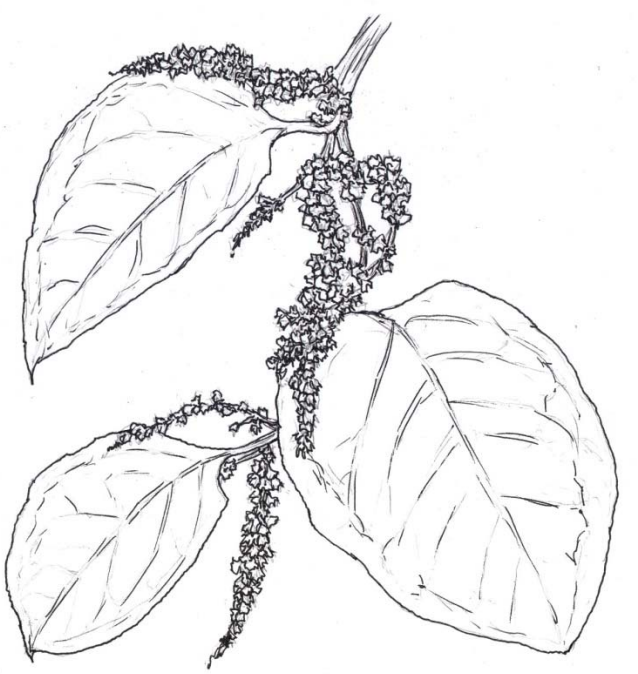
Japanese Knotweed *Polygonum cuspidalum*



JAPANESE KNOTWEED

USDA Symbol: POCU6

Description: Perennial; blooms July to October. Grows four to nine foot tall and has long creeping rhizomes. Stout stems reddish-brown, nodes slightly swollen. Leaves short stalked, trucate, broadly ovate and 2-6" long by 2-4" wide. Flowers greenish-white to cream in large plume-like clusters at the ends of the stems. Hybrids with giant knotweed are common.

Impacts: Japanese knotweed is a native of Eurasia and was introduced to the United States as an ornamental. Plants grow vigorously along roadsides, waste areas, streams and ditch banks and create dense colonies that exclude native vegetation and greatly alter natural tree regeneration. Established populations are extremely persistent and do not respond to mowing/cutting. Large infestations can be eliminated with approved herbicides, but treatments are costly and time consuming. It poses a significant threat in riparian areas, where it disperses during flood events rapidly colonizing scoured shorelines, islands and adjacent forest land.

Family: Smartweed (Polygonaceae) family
Other Names: Fallopia japonica, Pleuropterus zuccarinii, Polygonum japonicum, P. zuccarinii, P. sieboldii de Vriese, Reynoutria japonica, Japanese bamboo, Mexican bamboo, Japanese polygonum, Japanese fleeceflower, false bamboo, Kontiki bamboo, bombascus.
Origin and Distribution: Japanese knotweed was introduced from eastern Asia in the late 1800s as an ornamental, but soon escaped from gardens to colonize disturbed areas. By the 1960s it had spread to local infestations from Maine south to Virginia and west to Indiana. Today it is found from Nova Scotia to the Carolinas and west to Minnesota and Iowa, as well as in Colorado, Utah, and coastal areas from Washington to Northern California. It is found in urban and suburban landscapes, roadsides, gullies, and waste areas. It is particularly troublesome along riverbanks, edges of ponds, and other wet areas. It is often associated with moist but well-drained sites with nutrient-rich soil, and it tolerates semi-shaded environments. It has also been planted in sandy sea-shore areas where it stabilizes soil and withstands salt and low nutrients.

Plant Description: Japanese knotweed is an erect, broad-leaved, semi-woody perennial that spreads by long rhizomes and occasionally by seeds. The plant forms dense clumps that exclude other plants, and radiates rapidly to form patches that can be as large as 1 to 3 acres. It is one of the most persistent, and hardy of weeds, and it tolerates many control measures. Japanese knotweed is an invasive plant that can overrun natural areas, gardens, yards, roadsides, and utility and railroad rights-of-way.

Root system - The root system is fibrous, but rhizomes are white when young, becoming brown, thick, and woody with age. Rhizomes have prominent nodes with dark papery sheaths. They may be shallow or deep, and are responsible for the spread and persistence of this weed.
Seedlings & Shoots - Young shoots are reddish, with mostly heart-shaped leaves. Because seed production is uncommon, true seedlings are uncommon. Most young shoots arise from rhizomes.
Stems - Stems are erect, tall (up to 10 or more feet for mature stands), and hollow except at the prominent, swollen, knot-like nodes. The stems are thought to resemble those of bamboo. Attached to each node and surrounding the stem is a light green to brown, hairless, papery sheath.
Stems are round and smooth, red-brown at the base, and mottled green toward the tip. Stems die back to the ground during winter, but semi-woody stem bases persist.
Leaves - Leaves are alternate (one per node), broad, flat to round at the base, tapering to a pointed tip, and attached by long petioles. The upper leaf surface is dark green and the lower surface is pale green.
Flowers - Small, greenish white flowers are clustered along branching panicles arising from upper leaf axils. Plants are unisexual, with male and female flowers on separate plants. Male flower stalks are mostly erect and female flower stalks are drooping. When blooming (July to September), the plant puts on an attractive floral display befitting the common name 'fleece flower'.
Fruits & Seeds - Rarely produced fruits have three triangular papery wings surrounding a single dry, brown, triangular seed. Fruits are rare because colonies seldom contain a mixture of male and female plants.

Similar Species: Japanese knotweed resembles bamboo because of the robust hollow stems with distinct nodes and internodes; however, true bamboo is a grass. The broad and pointed Japanese knotweed leaves can be mistaken for Broadleaf dock (Rumex obtusifolia), but docks lack rhizomes and the tall, spreading habit of Japanese knotweed. Other less invasive relatives (such as P. virginianum) grow from similar rhizomes and are difficult to eradicate.

Biology: Japanese knotweed shoots resume growth in early spring, reaching a fast pace (reportedly 2 to 4 inches in a single day) and attaining heights over 10 ft. by late summer. Plants form dense colonies, spreading by rhizomes that can extend up to 65 feet. New colonies can regenerate from as little as a 1-inch piece of rhizome, which can easily be transported wherever soil is moved. Rhizomes send out shoots from April to August, even from a depth of over 3 feet. Shoots can even be initiated from internode tissue. Japanese knotweed exhibits great tolerance to most herbicides. It is reported to be a poor invader into grass cover and can be crowded out by taller trees. It does not survive frequent mowing.

Toxicity: Japanese knotweed has been used as a folk medicine in eastern Asia; however, this species contains tannins that were found to be carcinogenic. Large quantities of tannins were found to inhibit digestive enzymes in rats. Some chemicals isolated from Japanese knotweed have antimicrobial properties; others have been used as antioxidants and antimutagens in cancer research. Other chemicals isolated from this plant have been used to promote healing of burns, and still others to enhance the immune system and cardiac functions.

Related Information:

- ✓ Dense stands of Japanese knotweed exclude native and other desirable vegetation and reduce wildlife habit. It decreases water flow through rivers and streams and thereby contributes to flooding. It is a long-term threat because it occupies edges of woods and waterways that are valued for biological and visual diversity. It is one of the most troublesome weeds along railway rights-of-way, and is said to create a fire hazard in the dormant season.
- ✓ Japanese knotweed is highly regarded for its attractive flowers and has been planted by beekeepers for its nectar. It is also prized for its tolerance of harsh conditions like rocky soils with limited nitrogen and low pH. It has been planted along highways to control soil erosion and has been used for revegetation of strip-mine spoil and to stabilize land affected by volcanoes.

- ✓ Japanese knotweed has caused damage to sidewalks and parking lots where shoots have been able to grow up through concrete.
- ✓ Fast-growing branch tips picked in spring are said to be have a unique almond-like flavor when prepared in the manner of rhubarb pie.

Suggested Chemical Control

Dicamba (Banvel, Rifle, or Clarity)

Rate 0.25 lb ae dicamba mixed with 1 gal water/400 sq ft
Time Apply in late August to new regrowth since plant was cut back in June.
Remarks Apply as a basal spray to the stems at ground level.
Caution Do not apply in areas where roots of desirable plant species are growing.
Site of action Group 4: synthetic auxin
Chemical family Benzoic acid

Glyphosate

Rate Spot treatment: 0.06 lb ae (2.67 fl oz) glyphosate with 1 gal water
Time Apply as a coarse spray when weeds are actively growing and most are at bud to early flowering growth stage.
Remarks Spray for complete, uniform coverage but not to the point of runoff.
Caution Glyphosate is nonselective: it injures or kills any vegetation it contacts.
Site of action Group 9: inhibits EPSP synthase
Chemical family None generally accepted

Glyphosate (Roundup Pro Concentrate)

Rate Inject 5 ml/stem
Time Inject with a hand-held device into hollow stem of actively growing plants between second and third internodes.
Remarks Mark each stem when making the injection to avoid reapplying.
Caution Non-crop use only. Total of all treatments must not exceed 8.5 quarts/A of Roundup Pro Concentrate or 1,600 stems/A per year.
Site of action Group 9: inhibits EPSP synthase
Chemical family None generally accepted

Imazapyr (Arsenal or Habitat)

Rate 0.5 to 1 lb/A or 1% solution + 0.25% surfactant.
Time Apply in midsummer, after seedhead forms, up to killing frost.
Remarks Spray to cover plants but not to runoff. Habitat is labeled for aquatic sites.
Caution Before using, note crop rotation restrictions.
Site of action Group 2: acetolactate synthase (ALS) inhibitor
Chemical family Imidazolinone

Triclopyr ester (Garlon 4 or Remedy) or triclopyr amine (Garlon 3A) or triclopyr + 2,4-D ester (Crossbow)

Rate 0.5% to 2% concentration for application with a handgun sprayer.
Time Apply to actively growing plants in midsummer.
Remarks Adding 0.25% to 0.5% of a suitable surfactant to Garlon 3A improves results. No surfactant is needed with Garlon 4 or Remedy.
Caution Garlon products are registered for use on rights-of-way, industrial sites, and forestry (release and site preparation). Crossbow and Remedy can be used on permanent pastures and rangeland up to 1.5 lb ae/A. Observe all grazing and harvesting restrictions.
Site of action Group 4: synthetic auxin
Chemical family (triclopyr) pryidine; (2,4-D) phenoxy acetic acid

Japanese Spiraea *Spiraea japonica* L. f.

JAPANESE SPIRAEA

Common Names: Japanese spiraea, Japanese meadowsweet
Native Origin: Japan, Korea and China
Description: A perennial, deciduous shrub in the Rose family (*Rosaceae)* that grows to 4 to 6 feet in height and width. Erect stems are brown to reddish-brown, round in cross-section and sometimes hairy. The alternate eggshaped leaves are 1-3 inches long and have toothed margins. Rosy-pink flowers clusters up to 12 inches across are borne at the tips of branches. Seeds, measuring about 1/10 inch in length, are contained in small lustrous capsules.
Habitat: It is adapted to disturbed areas, tolerates a wide range of soil conditions and grows in full sun to partial shade. It is commonly found growing along streams and rivers, forest edges, roadsides, and in successional fields and power line right-of-ways.
Distribution: Japanese spiraea is now naturalized throughout much of the Northeast, Southeast and Midwest. This species is reported from states shaded on Plants Database map. It is reported invasive in KY, MD, NC, NJ, PA, TN, and VA.
Ecological Impacts: Japanese spiraea can rapidly take over disturbed areas. Growing populations creep into meadows, forest openings, and other sites. Seeds last for many years in the soil, making its control and the restoration of native vegetation especially difficult. A single plant produces hundreds of small seeds that are naturally dispersed by water and deposited along stream banks. Seeds may also be carried in fill dirt and establish new populations in the highly disturbed soil of construction sites.
Control and Management:
• **Manual**- Cutting or mowing Japanese spiraea shrubs may be effective for small, initial populations or for environmentally sensitive areas where herbicides cannot be used. Repeated mowing or cutting will control the spread of spiraea, but will not eradicate it. Spiraea resprouts after cutting, making repeated cutting necessary to exhaust the plants energy reserves. Stems should be cut at least once per growing season, prior to seed production, and cut as close to ground level as possible.
• **Chemical**- Foliar herbicide applications should be considered for large thickets of Japanese spiraea where the risk to non-target plants is determined to be minimal. Applications may be made almost any time of year, as long as the air temperature is above 65ºF, to ensure absorption of the chemical by the plant. It can be effectively controlled using any of several readily available general use herbicides such as glyphosate or triclopyr. Follow label and state requirements.

Leafy Spurge *Euphorbia esula See under Spurge*

Leafy spurge *Euphorbia esula*

Leafy spurge (*Euphorbia esula L.*) is a creeping, herbaceous perennial weed of foreign origin that reproduces from seed and vegetative root buds. It can reduce rangeland cattle carrying capacity by 50 to 75 percent. About half of this loss is from decreased grass production. Cattle won't graze in dense leafy spurge stands and these areas are a 100% loss to producers. Leafy spurge is difficult to control. Its extensive root system has vast nutrient stores that let it recover from control attempts. Combine control methods into a system to achieve best results. See page 55 for more detailed information.

Leafy spurge is a creeping perennial that emerges each year from roots that may be exceptionally deep in soil. This weed does not survive under regular cultivation. It becomes serious when it invades pastures and rangeland. Mowing is not effective and is usually impractical. Sheep will graze leafy spurge enough to reduce competition with grass and to allow some production from the rangeland. Any control program, including herbicides, must be long term. Picloram or two or three applications of glyphosate seem to be a good starting point. Establishing a competitive grass and using 2,4-D to prevent seed production and to slow the growth of survivors are essential to return the land to full productivity.

Suggested Chemical Control Management

2,4-D LV ester

Rate 1 lb ae/A helps prevent seed formation; 6 lb ae/A helps control leafy spurge infestations.
Time Use lower rates to prevent seed formation in the bud to early bloom stage. Use higher rates in early spring applications.
Remarks When mowing is possible, spray 2,4-D on new regrowth 2 week after mowing. Re-treatments will be necessary.
Caution Avoid drift to sensitive crops.
Site of action Group 4: synthetic auxin
Chemical family Phenoxy acetic acid

Aminocyclopyrachlor + chlorsulfuron (Perspective)

Rate 1.8 to 3.2 oz/A aminocyclopyrachlor + 0.7 to 1.3 oz/A chlorsulfuron (4.5 to 8 oz/A of product)
Time Apply to actively growing plants in spring.
Remarks Adjuvants can be used; these include methylated seed oils 0.5 to 1% v/v, nonionic surfactants at 0.25 to 1% v/v, and crop oil concentrates at 1% v/v. Can be applied using an invert emulsion rather than water.
Caution Even low rates can kill nontarget tree and shrub species, so avoid application within a distance equal to the tree height of the sensitive species. Do not allow spray to drift off target. Can injure several grass species including bromes, as well as basin wildrye.
Site of action Group 4 synthetic auxin (aminocyclopyrachlor) Group 2: ALS inhibitor (chlorsulfuron)
Chemical family Phenoxy acetic acid (aminocyclopyrachlor); sulfonylurea (chlorsulfuron)

Dicamba (Banvel, Rifle, or Clarity)

Rate 4 to 8 lb ae/A
Time Apply in spring or early summer.
Remarks Dicamba is both soil- and foliar-active. Use on non-cropland only at these application rates. Repeat each year as needed.
Caution Do not graze livestock in treated fields within 30 days of slaughter.
Site of action Group 4: synthetic auxin
Chemical family Benzoic acid

Fosamine (Krenite S)

Rate 2 gal product/100 gal water
Time Apply at flowering to actively growing plants. Apply spray to wet.
Remarks Will not kill grasses and can be used next to water. Effectiveness may be reduced if rain falls on the same day.
Caution Non-cropland use only.
Site of action Not well understood
Chemical family Organophosphorus

Glyphosate

Rate 0.38 to 0.75 lb ae/A
Time Applications must be split, at 30-day intervals. For the 0.38 lb ae/A (1 pint) rate, apply 1 pint of glyphosate about June 1, July 1, and August 1. For the 0.75 lb ae/A (2 pints) rate, apply 2 pints of glyphosate about June 1 and July 1.
Remarks Three split applications (0.38 lb ae/A each) are somewhat selective, leaving some perennial grasses. These treatments are suggested when water is near the infested area or when a reseeding of grasses is planned. Applications prevent vegetative growth the year of application and will prevent seed production the second year.
Caution Re-treatment is necessary for continued control. Glyphosate is not selective.
Site of action Group 9: inhibits EPSP synthase
Chemical family None generally accepted

Glyphosate + 2,4-D (Landmaster BW)

Rate 54 oz/A Landmaster
Time Late summer or fall.
Remarks Apply in 3 to 10 gal of water.
Caution Glyphosate is not selective; desirable grasses will be killed at this rate.
Site of action (glyphosate) Group 9: inhibits EPSP synthase; (2,4-D) Group 4: synthetic auxin
Chemical family (glyphosate) none generally accepted; (2,4-D) phenoxy acetic acid

Imazapic (Plateau)

Rate 0.125 to 0.188 lb ai/A
Time Apply in late summer or fall (mid-August through October) before spurge loses its milky sap due to drought or a killing frost.
Remarks Add 1 quart/A methylated seed oil.
Caution Before using, note crop rotation restrictions.
Site of action Group 2: acetolactate synthase (ALS) inhibitor
Chemical family Imidazolinone

Picloram (Tordon)

Rate 0.5 to 1 lb ae/A. Use higher rates in areas that are difficult to re-treat. Make a series of applications of 0.5 lb ae/A if leafy spurge is near running water or lakes.
Time Apply any time in the growing season. Re-treatments needed for several years to control seedlings.
Remarks Picloram has given excellent control with follow-up treatments. It can persist for 2 years at higher application rates.
Caution Most formulations are restricted-use herbicides. Do not contaminate water. Potatoes, beans, and many other broadleaf crops are sensitive to picloram. Do not use in diversified crop areas.
Site of action Group 4: synthetic auxin
Chemical family Pyridine

Always follow label instructions and take steps to avoid exposure. If any exposures occur, be sure to follow the First Aid instructions on the product label carefully. For additional treatment advice, contact the Poison Control Center at 1-800-222-1222. If you wish to report a pesticide problem, please call 1-800-858-7378.

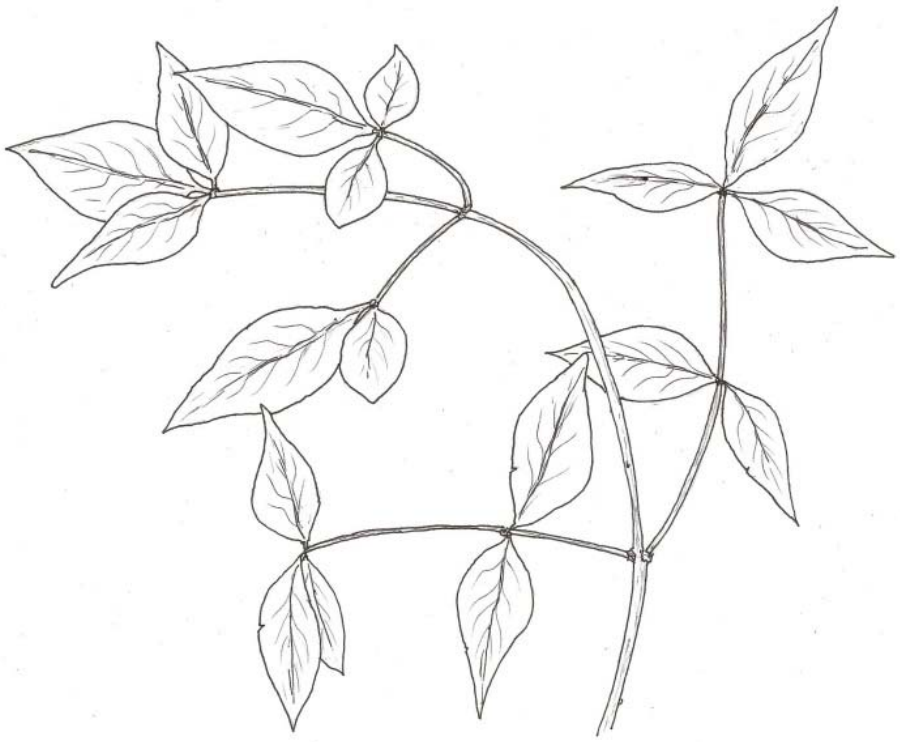
NOTE: When herbicides are used, it is the applicator's legal responsibility to read and follow directions on the product label. Not following label directions, even if they conflict with information provided herein, is a violation of federal law.

This publication contains pesticide recommendations that are subject to change at any time. These recommendations are provided only as a guide. It is always the pesticide applicator's responsibility, by law, to read and follow all current label directions for the specific pesticide being used. Due to constantly changing labels and product registration, some of the recommendations given in this writing may no longer be legal by the time you read them. If any information in these recommendations disagrees with the label, the recommendation must be disregarded. No endorsement is intended for products mentioned, nor is criticism meant for products not mentioned. The author and Technical Learning College (TLC) assume no liability resulting from the use of these recommendations.

USE PESTICIDES WISELY: ALWAYS READ THE ENTIRE PESTICIDE LABEL CAREFULLY, FOLLOW ALL MIXING AND APPLICATION INSTRUCTIONS AND WEAR ALL RECOMMENDED PERSONAL PROTECTIVE GEAR AND CLOTHING. CONTACT YOUR STATE DEPARTMENT OF AGRICULTURE FOR ANY ADDITIONAL PESTICIDE USE REQUIREMENTS, RESTRICTIONS OR RECOMMENDATIONS.

NOTICE: MENTION OF PESTICIDE PRODUCTS IN THIS COURSE DOES NOT CONSTITUTE ENDORSEMENT OF ANY MATERIAL.

Nandina *Nandina domestica* Thunb.



SACRED BAMBOO

Common Names: Nandina, sacred bamboo, heavenly bamboo
Native Origin: China, Japan, India; introduced to the United States and widely planted as an ornamental; now escaping and spreading from original plantings

Description: Evergreen erect shrub in the barberry family (Berberidaceae) that grows to a height of 6-10 feet and width of 3 to 5 feet (Other cultivars including dwarf nandina are shorter in height). The plant has multiple bushy cane-like stems that resemble bamboo. The alternate leaves are bi-pinnately compound dividing into many 1 to 2-inch, pointed, oval leaflets. Young foliage is often pinkish, and then turns to soft light green. The foliage can be tinged red in winter. Early summer terminal clusters of tiny white-to-pink flowers. Each flower is ¼ to ½ inch across, appearing in loose, erect, 6 to 12 inch clusters at the end of the branches. If plants are grouped, shiny red spherical berries, 1/3 inch in diameter, follow the flowers in fall and winter. Single plants seldom fruit heavily. It spreads both vegetatively through underground sprouts from roots and by seeds.

Habitat: It grows in full sun to shade and prefers reasonably rich soil but does not thrive in sand. It occurs under forest canopies and near forest edges.

Distribution: This species is reported from states shaded on Plants Database map. The bottom map shows potential areas for spread. Arkansas is an epicenter for nandina in forests. It has escaped intended plantings and found along roadsides and vacant lots in Kentucky and Ohio. It is reported to be invasive by the National Park Service in FL, GA, NC, and TN.

Ecological Impacts: Nandina has naturalized and invaded habitats. It colonizes by spreading underground root sprouts and by animal-dispersed seeds. It can persist as a seedling for several years before maturing. It can displace native species and disrupt plant communities.

Toxicity: Berries are can be toxic to cats and some grazing animals.

Control and Management:
• **Manual**- It is difficult to remove manually because even the smallest piece of root will re-sprout.
• **Chemical**- It can be effectively controlled using any of several readily available general use herbicides such as glyphosate or triclopyr. For tall plants, cut stems then apply herbicide. Collect and destroy fruit. Repeat applications may be necessary to reduce densities. Follow label and state requirements. Managers should evaluate the specific circumstances of each infestation, seek professional advice and guidance if necessary, and use the herbicide in a manner that is consistent with the product label and other state requirements
• **Natural pests**- Plants are bothered by scale and mites. Leaf spot diseases often cause the lower leaves to drop from the plant in the humid regions. The disease appears to be most severe on plants grown in partial shade where the foliage can remain wet.

Always follow label instructions and take steps to avoid exposure. If any exposures occur, be sure to follow the First Aid instructions on the product label carefully. For additional treatment advice, contact the Poison Control Center at 1-800-222-1222. If you wish to report a pesticide problem, please call 1-800-858-7378.

NOTE: When herbicides are used, it is the applicator's legal responsibility to read and follow directions on the product label. Not following label directions, even if they conflict with information provided herein, is a violation of federal law.

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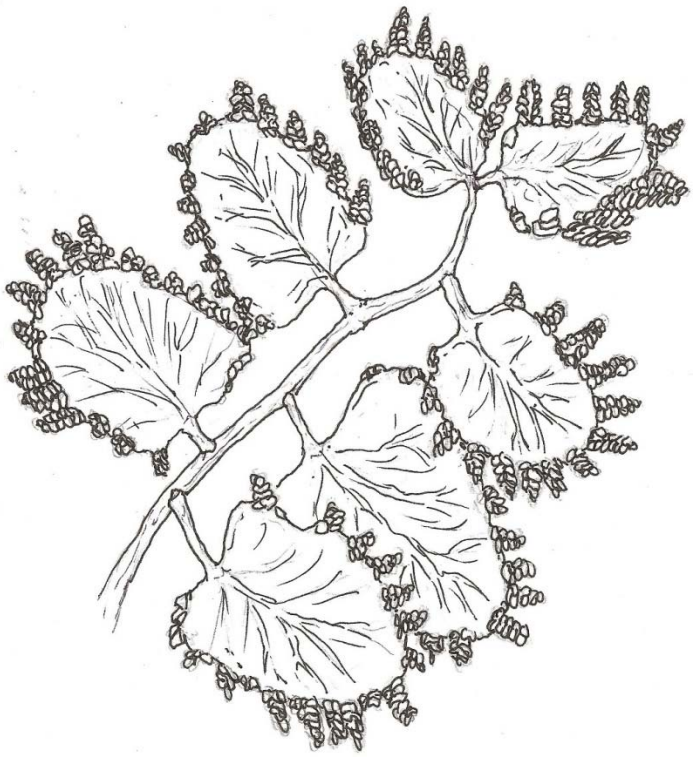
Old World Climbing Fern *Lygodium microphyllum*



OLD WORLD CLIMBING FERN

Old World climbing fern, *Lygodium microphyllum* (Cav.) R. Br. (Lygodiaceae), is an aggressive invasive weed of moist habitats in southern Florida (Pemberton and Ferriter, 1998). This rapidly spreading weed colonizes new areas without the need of habitat disturbance and frequently completely dominates native vegetation. Herbicidal and mechanical controls are expensive, temporary solutions, and are damaging to non-target plants. The fern, first found to be naturalized in 1965, has become one of the most dangerous weeds in southern Florida.

Nature of Damage

Economic damage. Although primarily a weed of natural areas, L. microphyllum infests residential landscapes, horticultural nurseries, and other managed lands near infested natural vegetation. Current control costs for chemical control of L. microphyllumrange from $325 to $1,250/ha (D. Thayer, pers. comm.). But for areas that are hard to reach, such as the L. microphyllum infestations on the Loxahatchee National Wildlife Refuge in Florida, the cost for a single application was $3,750/ha in 2000, and since the fern has regrown the infestations were retreated in 2001 (M. Bailey and W. Thomas, pers. comm.).

Ecological damage. Lygodium microphyllum's ability to grow up and over trees and shrubs and to run horizontally allows it to smother whole communities of plants reducing native plant diversity. It is difficult for other plants to grow through the thick fern mats (up to 1 m thick). Lygodium microphyllum is common in bald cypress (Taxodium distichum [L.] Richard) stands, but also infests pine flatwoods, wet prairies, saw grass (Cladium jamaicense Crantz) marshes, mangrove communities, Everglades tree islands, and disturbed areas. Some Everglades tree islands are so completely blanketed by the fern that it is not possible to see trees and other vegetation beneath the fern mat.

Lygodium microphyllum also threatens rare plants. In Loxahatchee Slough in Palm Beach County, Florida, the fern is an "imminent danger" to Tillandsia utriculata L. and other rare bromeliads (Craddock Burks, 1996). Infestations of this fern alter the impact of fire, which is a naturally occurring element and a management tool in many Florida communities (Roberts, 1998).

Thick skirts of old fronds enclose trees and serve as ladders that carry fire into tree canopies. Trees that can withstand ground fires are killed when fire is brought into the canopy. Fires that usually terminate at the margins of cypress sloughs during the wet season can burn into and through cypress sloughs infested with L. microphyllum. Portions of burning fern also can break free and spread fire to new areas. Lygodium microphyllum appears to be long-lived and persistent, and can occupy a large proportion of suitable habitats in a relatively short time. The fern is classified as a Category I invasive species (the most invasive species) by the Florida Exotic Plant Pest Council (Langeland and Craddock Burks, 1998).

Extent of losses. It is hard to quantify the extent of the losses due to Old World climbing fern. The explosive growth and rapid spread of the fern are relatively recent. It was first collected from Jonathan Dickinson State Park in Palm Beach County in 1966 (Beckner, 1968), and by 1993, it was present on 493 ha (11%) of the park and the Loxahatchee National Wild and Scenic River (Roberts, 1998). In 1995, the weed was present on 6,800 ha (12%) of the Loxahatchee National Wildlife Refuge (Palm Beach Co.), where it was undetected in 1990 (S. Jewel, pers. comm.). The land area infested by this fern is estimated (from aerial surveys) to have increased 150% between 1997 and 1999 (A. Ferriter, pers. comm.). Present losses due to this weed are bad, yet modest compared to potential losses unless effective controls can be found and implemented soon.

Geographical Distribution

In the United States. *Lygodium micophyllum* is a subtropical and tropical plant that requires shallow aquatic habitats or moist soils. At present, *L. microphyllum* is limited to the southern third of the Florida peninsula from Brevard and Highlands County south. The area with the lowest winter temperatures currently infested is Polk and Highlands Counties (ca. 28°N) in south-central Florida. These areas are in the USDA Plant Hardiness Zone 9B (minimum of 3.9 to 6.6°C) (Cathey, 1990). Because Zone 9B extends up the eastern coast to the Georgia border (ca. 30°N), the weed may well be able to colonize this area. Zone 9B extends to just above Tampa on the west coast of Florida. If spores of the fern are carried across the Gulf of Mexico to the southern coast of Texas and Mexico, the weed could establish in those areas because of suitable climates and habitats. If it establishes in Mexico, it could spread south to much of wet tropical America. Lygodium microphyllum also is naturalized to a limited extent in Jamaica and Guyana (Pemberton and Ferriter, 1998), so the opportunity for it to spread within the Caribbean and other tropical portions of the Americas already exists.

Native range. *Lygodium microphyllum* has an exceptionally large native range, occurring in much of the moist Old World tropics and subtropics (Pemberton, 1998). The fern's temperate limits are between 28°S and 29°S in Australia and South Africa, and 25° N and 27°N in Assam (northeastern India) and the Ryuku Islands (the southwestern most part of Japan). It spans more than half of the world's circumference from 18°E in Senegal to 150°W in Tahiti. In Africa, *L. microphyllum* ranges from Senegal south and east through most of West Africa to Zaire, then south to Angola, east to East Africa, and then south to South Africa. In Asia, the fern is distributed from India and Nepal, east through much of Southeast Asia, and north through the warmer provinces of southern China to Taiwan and Okinawa. It also occurs throughout many of the Southeast Asian islands to Australia and, in the Pacific, east to Tahiti.

Taxonomy

The correct name of Old World climbing fern is *L. microphyllum* (Alston and Holttum, 1959; Hanks, 1998), but the species is occasionally referred to as *Lygodium scandens* (L.) Sw., particularly in older works. As many as 40 species have been placed in the genus Lygodium (Mabberley, 1997), but a recent revision has reduced this number to 26 (Hanks, 1998).

All but two species are from areas with tropical or subtropical climates. The genus Lygodium has usually been placed in the Schizaeaceae, a small primitive family that also includes the genera Actinostachys, Schizaea, Anemia, and Mohria (Prantl, 1881; Holttum, 1973; Hanks, 1998). Since Lygodium is unique morphologically, it is sometimes interpreted to comprise its own monogeneric family, the Lygodiaceae (Bierhorst, 1971; Wagner and Smith, 1993). The relationship of the Schizaeaceae (Lygodiaceace s.s.) to other groups of ferns is unclear (Smith, 1995).

Lygodium microphyllum is a distinctive fern in North America. This vine has pinnately compound fronds (pinnules), except the sterile fronds (pinnae), which have entire margins. *Lygodium japonicum* (Thunberg ex.

Murray) Swartz, another invasive species in the southeastern United States, has twice pinnately compound fronds with sterile fronds that have toothed margins. Lygodium palmatum (Bernh.) Sw., a temperate native member of the genus living from Appalachia north to New England, has palmately compound fronds. *Lygodium microphyllum* has been placed, based on morphology, in the subgenus Volubilia; the native *L. palmatum* in the subgenus Palmata; and *L. japonicum* in the subgenus Flexuosa (Prantl, 1881; Hanks, 1998).

Biology

The biology of *L. microphyllum* is not well studied. The fern is a long-lived perennial vine. The aerial vines are actually very long leaves with a stem-like rachis and leaflet-like pinnae and pinnules comprising the photosynthetic tissue. The plant bears both fertile leaflets with sporangia bearing teeth along the edge of the blade, and sterile leaflets with entire margins. The true stems are underground rhizomes. These vines can be 30 m in length. Growth and sporulation appear to occur all year. The fern produces large numbers of spores; more than 800 spores/m3/hour were trapped in one Florida infestation (Pemberton and Ferriter, 1998). Spores can germinate in six to seven days (Brown, 1984). Dried spores taken from the plants have germinated after two years (Lott and Pemberton, unpub.). The life cycle of *L. microphyllum* is the same as with other ferns. The spores require moist conditions to germinate and grow into small, liverwort-like gametophytes. Male and female organs are produced on the same gametophytes and fertilization occurs when the swimming spermatozoid swims from the male organ to a female organ to penetrate the ovule. Fertilization gives rise to the familiar large leafy fern, which is the sporophyte stage. The fern spreads locally by vegetative growth and over long distances by wind-borne spores. The plant can grow in standing water and wet soils, and either in full sun or shade.

Analysis of Related Native Plants in the Eastern United States

In addition to *L. palmatum* (discussed above), there are West Indian Lygodium species that are being considered in the biological control program because of the proximity of this region to southern Florida. Lygodium volubile Sw., which occurs in Cuba and other areas of the West Indies, belongs to the same subgenus Volubilia as L. microphyllum. *Lygodium cubense* Kunth. (a Cuban endemic), *Lygodium venustum* Sw. (found in the West Indies), and *Lygodium oligostachyum* (Willd.) Desv. (endemic to the Dominican Republic and Haiti) (Prantl, 1881; Hanks, 1998) all belong to the subgenus Flexuosa.

Except for *L. palmatum*, the only native North American plants that have been considered related to *L. microphyllum* are three species of Anemia, one species of Actinostachys, and one species of Schizaea (Wagner and Smith, 1993; Nauman, 1993; Mickel, 1993). Anemia mexicana Klotzsch occurs in southwest Texas and northern Mexico. *Anemia adiantifolia* (L.) Swartz is locally common in Florida and the West Indies. Anemia wrightii Baker in Hooker and Baker is a tiny rare fern limited to lightly shaded solution holes and limestone sinks in southern Florida and the West Indies.

Both Florida Anemia species are broadly sympatric with L. microphyllum. Schizaea pusilla Pursh is found in the northeastern part of North America. *Actinostachys pennul*a (Swartz) Hooker is a widely distributed species in tropical America whose only known North American population is on Everglades tree islands that are being overgrown by *L. microphyllum*.

The relationships among the genera of the Schizaeaceae S.l. are unclear (Smith, 1995). Recent molecular research (rbcL) on the phylogeny of ferns found that Lygodium, Actinostachys, and Anemia have more intrageneric distance than occurs between most fern families (Hasebe et al., 1995). The research also showed the family to be very isolated, with more intrafamilial distance between it and other fern families than occurs between most fern families (Hasebe et al., 1995).

The molecular data and the antiquity of the Schizaeaceae (Anemia spores are known from the Cretaceous [Smith, 1995]), suggest that the family arose earlier than other fern groups.

History of Biological Control Efforts in the Eastern United States
Area of Origin of Weed
While the native range of *L. microphyllum* is well defined, it is very large and the area(s) of origin of the plants that have become invasive in Florida is unknown. To attempt to identify the region(s) of origin of the Florida plants, collections of Florida material and material from many different parts of the native range are being made for genetic comparison. The weed is of horticultural origin in Florida (Pemberton and Ferriter, 1998). It was recognized to be a potential problem not long after it was found to be naturalized (Nauman and Austin, 1978).

Areas Surveyed for Natural Enemies
A preliminary survey for the natural enemies of *Lygodium* spp. was made in Japan, northern Taiwan, and Hong Kong during the autumn of 1997 by R. Pemberton. *Lygodium japonicum*, the only Lygodium in Japan, was common in central and western Honshu, including Tokyo. *Lygodium microphyllum* was uncommon in northern Taiwan; only one population was found. In Hong Kong, *L. microphyllum*, *L. japonicum*, and *Lygodium flexuosum*(L.) Swartz were examined. *Lygodium microphyllum* occurred in small patches, a few meters wide, along streams and on hillsides in heavy soils. The discovery of various pyralid moths attacking the plants helped secure funding for the project.

Much of the exploratory effort for Lygodium natural enemies is being carried out by J. Goolsby and T. Wright. This effort began in 1998 and is focused on *L. microphyllum* and other *Lygodium* spp. (*L. japonicum*, *L. flexuosum*, and *Lygodium reticulatum* Schkuhr, Farnkr.) in Southeast Asia and Australia. Lygodium microphyllum is widely distributed throughout the wet tropics and subtropics of Australia and Southeast Asia. Within Australia areas in New South Wales, Queensland, the Northern Territory, and Western Australia were explored. In southeast Asia, areas in Indonesia, Malaysia, Singapore, and Thailand were surveyed.

Several trips have been made to each of the collection locations to capture the seasonal diversity of herbivores, and more than 250 sites have been visited. In these areas, *L. microphyllum* is not weedy and is associated with a complex of insects, mites, and pathogens. *Lygodium microphyllum* and *Lygodium smithianum* Pres. were surveyed in West Africa (Benin, Ghana, and Cameroon) by R. Pemberton in 1999. West Africa is at the western edge of *L. microphyllum*'s huge Old World distribution. The plant was found in both swamps and in diverse terrestrial habitats in high rainfall areas. The plant often was common, but not abundant or dominant.

Two short visits were made by cooperators to a *L. microphyllum* population in Natal South Africa, near the plant's southern latitudinal limit.

Natural Enemies Found
More than 18 species of herbivores have been collected from *L. microphyllum* (Table 1). The pyralid moth Neo Musotima conspurcatalis Warren is the most widely distributed, followed by an eriophyid mite in the genus Floracarus. Most efforts to locate natural enemies have focused on the above-ground portions of the fern. Searching methods have included visual inspection, beating trays, and black-light trapping.

Quackgrass *Elytrigia repens*

QUACKGRASS

Quackgrass, a creeping perennial, is a very aggressive grass and is considered a noxious weed in most states. It spreads by seeds and invasive rhizomes (underground stems). Its rhizomes are yellow-white, with brown sections, and the ends are sharply pointed.

Control A few quackgrass plants can be spot-sprayed with glyphosate, or individual blades can be painted with glyphosate. Note that glyphosate will kill any bluegrass it contacts. Repeat applications to quackgrass will likely be needed. Renovate severely infested lawn areas. Spray with glyphosate; repeat applications will likely be needed. When the quackgrass has been killed, the areas may be re-sodded or re-seeded. Always read the label before applying any pesticide.

Suggested Chemical Management and control options
Bromacil + diuron (Krovar I DF)

Rate 9.6 lb ai/A (12 lb/A)
Time Apply before weeds emerge.
Remarks Rain is needed to activate this herbicide.
Caution Nonselective weed control. Do not apply to areas where desirable plant roots extend.
Site of action (bromacil) Group 5: photosystem II inhibitor; (diuron) Group 7: photosystem II inhibitor
Chemical family (bromacil) uracil; (diuron) urea

Dichlobenil (Casoron)

Rate 4 lb ai/A in berries; 4 to 6 lb ai/A in fruit trees and grapes
Time Apply midwinter immediately before a cold rain to reduce volatility and enhance weed suppression. Weigh and distribute uniformly exact quantities over precisely measured areas. Oregon results over 9 years suggest that perennial weeds can be suppressed with 4-, 3-, and 2-lb ai/A rates applied in 3 consecutive years. Grazing livestock is prohibited. Inhibits cellulose and cell wall formation.
Remarks Selective in trailing berries, fruit trees, and grapes.
Site of action Group 20: inhibits cell wall synthesis Site A
Chemical family Nitrile

EPTC (Eptam)

Rate 4 lb ai/A
Time Apply in early spring or fall before plowing.
Remarks This application has been promising for selective control of quackgrass in such crops as beans, potatoes, and small-seeded legumes. It does not eradicate quackgrass but does reduce growth for the season and greatly reduces amount of live roots. Before EPTC applications, soil is disked or rotated until quackgrass rhizomes are 3 to 4 inches long.
Caution Apply to soil and immediately follow with a thorough disking in two directions to uniformly incorporate 6 inches deep.
Site of action Group 8: lipid synthesis inhibitor but not an ACCase inhibitor
Chemical family Thiocarbamate

Fluazifop (Fusilade DX)

Rate 0.25 to 0.375 lb ai/A (1 to 1.5 pints/A) for first application. If reapplication is needed, use 0.19 to 0.375 lb ai/A (0.75 to 1.5 pints/A).
Time Apply late spring to actively growing quackgrass 6 to 10 inches tall.
Remarks Apply with 1% v/v crop oil concentrate or 0.25% v/v nonionic surfactant. Repeat application to control established quackgrass. Acts very slowly, taking at least 2 and often 4 weeks to show effects. Do not apply to stressed grasses. Do not mix with other pesticides unless recommended on label.
Caution Do not graze treated fields.
Site of action Group 1: acetyl CoA carboxylase (ACCase) inhibitor
Chemical family Aryloxyphenoxy propionate

Glyphosate

Rate Broadcast: use 1 to 2.25 lb ae/A. Nonsodded quackgrass: use 0.75 to 1.5 lb ae/A (1 to 2 quarts). Sodded quackgrass: use 1.5 to 2.25 lb ae/A (2 to 3 quarts).
Time Apply during fallow periods in cropping systems when quackgrass is in late boot to early flowering stage.
Remarks Foliage must be thoroughly wet, but avoid runoff.
Caution Glyphosate is nonselective. Re-treatment may be necessary for complete control.
Site of action Group 9: inhibits EPSP synthase
Chemical family None generally accepted

Pronamide (Kerb)

Rate 2 to 3 lb ai/A
Time Apply during fall or winter when soil moisture is good and more precipitation is expected. Apply before ground freezes in the cooler areas.
Remarks Use higher application rates in heavier soil types.
Caution A restricted-use herbicide. Follow label for crop rotations.
Site of action Group 3: microtubule assembly inhibitor
Chemical family Benzamide

Russian Knapweed *Acroptilon repens See Knapweed for more info*

RUSSIAN KNAPWEED

Russian knapweed (*Acroptilon repens*) is a creeping, herbaceous perennial of foreign origin that reproduces from seed and vegetative root buds. Shoots or stems, are erect, 18 to 36 inches tall, with many branches. Lower leaves are 2 to 4 inches long and deeply lobed. Upper leaves are smaller, generally with smooth margins, but can be slightly lobed.

Shoots and leaves are covered with dense gray hairs. The solitary, urn-shaped flower heads occur on shoot tips and generally are 1/4 to 1/2 inch in diameter with smooth papery bracts.

Flowers can be pink, lavender or white. Russian knapweed has vertical and horizontal roots that have a brown to black, scaly appearance, especially apparent near the crown.

Russian knapweed emerges in early spring, bolts in May to June, and flowers through the summer into fall.

Russian knapweed is toxic to horses. The key to Russian knapweed control is to stress the weed and cause it to expend nutrient stores in its root system. The best management plan includes cultural controls combined with mechanical and/or chemical control techniques.

Suggested Chemical Management Options
The following herbicides usually control treated plants. Plants often regrow, so plan annual applications for several years. Control of regrowth and of new seedlings is much better if a competitive crop or sod is established. A perennial grass is the logical choice because, except for glyphosate, the herbicides listed here will not kill established grasses.

2,4-D

Rate 1 to 2 lb ae/A (4 to 8 lb ae/A for Russian knapweed)
Time Apply at the early stage of flower stem elongation (late April to early May).
Remarks Treatment will control only plants emerged at time of spraying.
Caution Avoid drift to sensitive crops.
Site of action Group 4: synthetic auxin
Chemical family Phenoxy acetic acid

Aminocyclopyrachlor + chlorsulfuron (Perspective)

Rate 1.8 to 3.2 oz/A aminocyclopyrachlor + 0.7 to 1.3 oz/A chlorsulfuron (4.5 to 8 oz/A of product)
Time Apply to actively growing plants in spring.
Remarks Adjuvants can be used; these include methylated seed oils 0.5 to 1% v/v, nonionic surfactants at 0.25 to 1% v/v, and crop oil concentrates at 1%v/v. Can be applied using an invert emulsion rather than water.
Caution Even low rates can kill nontarget tree and shrub species, so avoid application within a distance equal to the tree height of the sensitive species. Do not allow spray to drift off target. Can injure several grass species including bromes, as well as basin wildrye.
Site of action Group 4 synthetic auxin (aminocyclopyrachlor) Group 2: ALS inhibitor (chlorsulfuron)
Chemical family Phenoxy acetic acid (aminocyclopyrachlor); sulfonylurea (chlorsulfuron)

Aminopyralid (Milestone)

Rate 1 to 1.75 oz ae/A (4 to 7 fl oz/A Milestone). Rate of application will depend on knapweed species to be controlled.
Time Consult label for optimum timing. Diffuse and spotted knapweed: apply to actively growing plants in fall or in spring from rosette to bolting growth stages. Russian knapweed: apply in spring and summer to plants from bud to flowering stage; in fall, to dormant plants.
Remarks A nonionic surfactant at 1 to 2 quarts per 100 gal of spray enhances control under adverse environmental conditions.
Caution Do not allow drift to desirable vegetation. Many forbs (desirable broadleaf plants) can be seriously injured or killed. Do not exceed 7 fl oz/A Milestone per year.
Site of action Group 4: synthetic auxin
Chemical family Pyridine

Clopyralid (Stinger or Transline)

Rate 0.25 to 0.5 lb ae/A (0.66 to 1.33 pints/A). Labeled rates vary with crops.
Time Up to the bud stage of knapweeds.
Remarks Results are best if applied to actively growing weeds. See labels for registered sites.
Caution Consult label for crop rotation restrictions before using Stinger. Several crops may be injured up to 4 years after application.
Site of action Group 4: synthetic auxin
Chemical family Pyridine

Clopyralid + 2,4-D amine (Curtail)

Rate 2 to 4 quarts/A Curtail
Time Apply after most rosettes emerge but before flower stem elongates.
Remarks Lower rate for in-crop cereal grain application; higher rates for fallow, postharvest, and Conservation Reserve Program (CRP) applications. Consult label for specific directions. CRP applications for established grass only. Apply in enough total spray volume to ensure good coverage for diffuse and spotted knapweed.
Caution Consult label for crop rotation restrictions before using product. Several crops may be injured up to 4 years after application.
Site of action Group 4: synthetic auxin
Chemical family (clopyralid) pyridine; (2,4-D) phenoxy acetic acid

Diflufenzopyr + dicamba (Overdrive)

Rate 0.26 to 0.35 lb ae/A (6 to 8 oz/A)
Time Apply to rosettes.
Remarks Add a surfactant to the spray mix.
Caution Avoid drift to sensitive crops. Will kill legumes.
Site of action (diflufenzopyr) Group 19: inhibits indole acetic acid transport; (dicamba) Group 4: synthetic auxin
Chemical family (diflufenzopyr) semicarbazone; (dicamba) benzoic acid

Glyphosate

Rate 3 lb ae/A
Time Apply to actively growing knapweed when most plants are at bud stage.
Remarks Glyphosate kills many knapweed plants but also kills grass that might compete with new knapweed seedlings. Russian knapweed is not controlled. When using glyphosate, follow by seeding with a locally adapted grass.
Site of action Group 9: inhibits EPSP synthase
Chemical family None generally accepted

Imazapic (Plateau)

Rate 0.188 lb ai/A for Russian knapweed
Time Apply in fall or early winter after Russian knapweed has grown old.
Remarks Use 1 quart/A methylated seed oil as the adjuvant. Selective to most native grasses. Higher rates may suppress seed of some cool-season grasses.
Caution Before using, note crop rotation restrictions.
Site of action Group 2: acetolactate synthase (ALS) inhibitor
Chemical family Imidazolinone

Picloram (Tordon)

Rate 0.25 to 0.5 lb ae/A (1 lb ae/A for Russian knapweed)
Time Apply in late spring before or during flower stem elongation.
Remarks A selective treatment that, at the suggested rate, will not damage perennial grasses. Treatment made in bud stage may not prevent seed production in the year of application. However, seed germination is markedly reduced.
Caution Most formulations are restricted-use herbicides. Do not contaminate water or use in diversified crop areas. Potatoes, beans, and most other broadleaf crops are sensitive to picloram.
Site of action Group 4: synthetic auxin
Chemical family Pyridine

Triclopyr + clopyralid (Redeem R&P)

Rate 1.5 to 2 pints/A (2.5 to 4 pints/A for Russian knapweed)
Time Apply from rosette to early bolt stage when weeds are actively growing. Russian knapweed should be in early bud to early flower growth stage.
Remarks Add a nonionic surfactant at surfactant manufacturer's recommended rate. Apply in at least 10 gal/A water by ground.
Caution Do not exceed 4 pints/A per year. Do not allow drift to desirable vegetation. Note label restrictions on overseeding or reseeding.
Site of action (both) Group 4: synthetic auxin
Chemical family (both) pyridine

Russian Thistle *Salsola tragus L. Salsola iberica*

(Sennen & Pau) Botch. ex Czerepanov,
Salsola kali ssp. ruthenica (Iljin) Soo, Salsola kali ssp. tenuifolia Moq.,
Salsola pestifer A. Nels.) ***See thistle for more information***

Russian Thistle *Salsola iberica*

Chenopodiaceae (Goosefoot family)
Origin: Eurasia
Location: open, abandoned gardens, waste areas, roadsides, fence rows, rangeland, cropland, and waterways
Occurrence: Seeds germinate from mid-spring through summer, generally within a temperature range of 52º-90 º F.
Flowering takes place from early to late summer. Flowers produce seeds which are mature by late fall. When frost kills the plant, the brittle upper portion breaks off at the base and tumbles in the wind.

Description: An upright summer annual that grows between 4 inches and 3 feet tall, and usually not as wide. The plant is highly branched from the base upward and forms a rounded to pyramidal shape. Most branches arch upward. Stems are round and rigid with vertical, reddish-purple stripes, turning grayish-brown at death. Young leaves are succulent, linear and 1 inch long. Mature leaves are arranged alternately on the stem, are stiff, short and wider at the base, with a spiny tip. Inconspicuous pink to greenish-white flowers are borne singly in leaf axils, sitting in a cavity created by the leaf and two small, spiny bracts. Flowers measure 3/16 - 1/2 inch in diameter. As they mature, the flower parts dry to produce papery wings surrounding a conical fruit. The fruit houses one brown, coiled seed.

Weedy Characteristics: A large Russian thistle plant can produce over 200,000 seeds, which are widely dispersed in the wind by the tumbling process, but also by transport on animal fur and on soil clinging to shoes and wheels. Its tap root can grow 3 feet deep, with many vigorous lateral roots, and its seed is known to germinate within a few hours after a small amount of rain.

These traits allow it to thrive in drought conditions. Russian thistle will grow in poor, salty soils (hence the scientific name, Salsola, which means “salty”), which are inhospitable to most plants. It is also suspected to produce substances that interfere with the growth of other nearby plants.

Control: Russian thistle seeds need loose soil to germinate, and seedlings do best in an open, dry environment. Desirable plants that become established early in the season will create shade that Russian thistle seedlings cannot tolerate. Maintaining a vigorous garden, with little to no bare soil will greatly discourage Russian thistle colonization. As an annual, Russian thistle reproduces solely by seed. Seeds generally do not remain viable past one year. Repeated hoeing, tilling, or mowing of young plants will prevent seed production. Hand-pulling (with gloves) can also be effective for small infestations. Mowing or tilling mature plants will likely help spread seeds. For current chemical or biological methods, consult your local state or county weed specialist.

Control Control of Russian thistle is difficult. There have been numerous attempts through the years to import biological control agents, but none have been successful.

Pre-emergent herbicides are applied to the soil before the weed seed germinates and are usually incorporated into the soil with irrigation or rainfall. The most effective pre-emergent herbicides are Aatrex (atrazine), Velpar (hexazinone), Devrinol (napropamide), Telar (chlorsulfuron), Oust (sulfometuron), Princep (simazine) and Hyvar (bromacil). Other pre-emergent herbicides that are registered but only moderately effective in controlling Russian thistle are Surflan (oryzalin), Treflan (trifluralin), Prowl (pendimethalin), Endurance (prodiamine), Lasso (alachlor), Predict (norflurazon), and Kerb (pronamide).

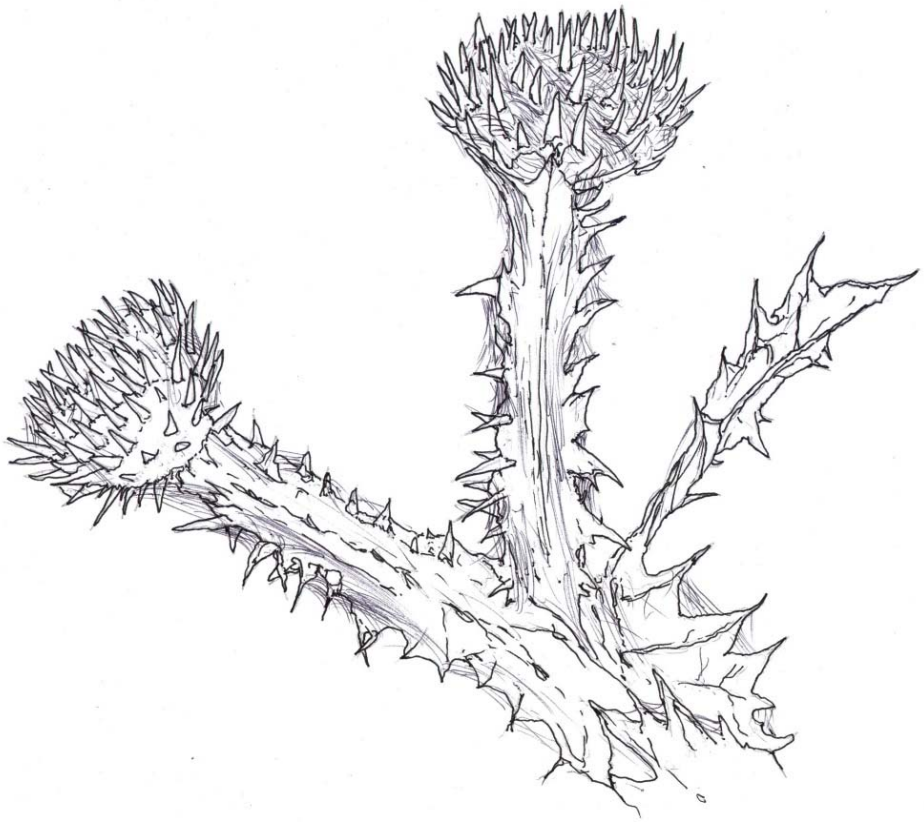
Herbicide-resistant biotypes of Russian thistle have evolved in only a couple of years following treatment with Telar (chlorsulfuron) or Oust (sulfometuron). Avoid repeated use of a single herbicide or of herbicides that have the same mode of action to prevent the evolution of herbicide-resistant populations.

Post-emergent herbicides are applied to plants, but timing is critical. For best results, these herbicides must be applied while the weed is in its early growth stages, preferably the early seedling stage, before it becomes hardened and starts producing its spiney branches. Do not use post-emergent herbicides to try to control the mature seed (either on the plant or on the ground) as they are not effective for this purpose. Also, the later spiney stage of Russian thistle is not readily controlled by any post-emergent herbicide. If rain or irrigation occurs after a post-emergent application, additional seedlings may emerge and require future treatments. Post-emergent herbicides that are effective when properly applied include Banvel or Vanquish (dicamba), Roundup (glyphosate), 2,4-D and Gramoxone (paraquat).

General Facts: Native people have been known to eat the young plants and the roasted seeds of Russian thistle, and to use the plant for several different medicinal purposes. Small animals and birds rely on Russian thistle for protective cover, and grazing animals often eat its early growth. It is, in fact, quite high in protein, but in some circumstances it can also accumulate levels of toxic substances that can be harmful to some livestock. Some people are allergic to Russian thistle pollen, and sensitive skin can be irritated when handling the plant. When dry, Russian thistle spines can damage animal mouths, as well. Russian thistle often serves as a host to insect pests that cause viral disease in vegetable crops. Dry tumbleweeds can be an extreme fire hazard, especially when they collect along fence lines, or other such areas. Travelling tumbleweeds also compromise road safety, and interfere with crop harvesting operations. Russian thistle is sometimes confused with--and will hybridize with--a closely related plant, barbwire Russian thistle (S. paulsenii), which is rounder, stiffer, and more spiny. Russian thistle is noxious in four U.S. states and five Canadian provinces, and it is considered invasive in 10 other U.S. states.

Other Common Names: prickly Russian thistle, prickly saltwort, Russian cactus, tartor thistle, tumbleweed, windwitch.

Scotch Thistle *Onopordum acanthium*
For more information see Thistle



SCOTCH THISTLE

Scotch thistle is a branched, robust biennial (or sometimes annual) that often grows 8 feet or more in height and 6 feet in width. Main stems may be up to 4 inches wide at the base. Stems have vertical rows of prominent, spiny, ribbon-like leaf material or "wings" that extend to the base of the flower heads. Leaves, which are armed with sharp, yellow spines, are up to 2 feet long and 1 foot wide.

Upper and lower leaf surfaces are covered with a thick mat of cotton-like or woolly hairs, which give the foliage a gray-green appearance. Plants flower in mid-summer. The globe-shaped flower heads are borne in groups of 2 or 3 on branch tips. Flower heads are up to 2 inches in diameter, with long, stiff, needle-like bracts at the base. Flowers range from dark pink to lavender. Seeds are smooth, slender, and plumed.

Suggested Chemical Control and Management Options
Thistle, bull (*Cirsium arvense*), Thistle, milk (*Silybum marianum*), Thistle, musk (*Carduus nutans*), Thistle, Scotch (*Onopordum acanthium*)

2,4-D

Rate 1.5 to 2 lb ae/A
Time Spring or fall.
Remarks Use fall treatments to control rosettes of these biennial weeds. Use spring treatments before flower stalk elongates. Annual treatments are needed to control seedlings. Pasture legumes are injured or eliminated at these rates.
Caution Avoid drift to sensitive crops.
Site of action Group 4: synthetic auxin
Chemical family Phenoxy acetic acid

Aminocyclopyrachlor + chlorsulfuron (Perspective)

Rate 1.8 to 3.2 oz/A aminocyclopyrachlor + 0.7 to 1.3 oz/A chlorsulfuron (4.5 to 8 oz/A of product)
Time Apply to actively growing plants in spring.
Remarks Adjuvants can be used; these include methylated seed oils 0.5 to 1% v/v, nonionic surfactants at 0.25 to 1% v/v, and crop oil concentrates at 1%v/v. Can be applied using an invert emulsion rather than water.
Caution Even low rates can kill nontarget tree and shrub species, so avoid application within a distance equal to the tree height of the sensitive species. Do not allow spray to drift off target. Can injure several grass species including bromes, as well as basin wildrye.
Site of action Group 4 synthetic auxin (aminocyclopyrachlor) Group 2: ALS inhibitor (chlorsulfuron)
Chemical family Phenoxy acetic acid (aminocyclopyrachlor); sulfonylurea (chlorsulfuron)

Aminopyralid (Milestone)

Rate 0.75 to 1.25 oz ae/A (3 to 5 fl oz/A Milestone)
Time Apply in spring or early summer to rosettes or bolting plants or in fall to seedlings and rosettes.
Remarks A nonionic surfactant at 1 to 2 quarts per 100 gal of spray enhances control under adverse environmental conditions.
Caution Do not allow drift to desirable vegetation. Many forbs (desirable broadleaf plants) can be seriously injured or killed. Do not exceed 7 fl oz/A Milestone per year.
Site of action Group 4: synthetic auxin
Chemical family Pyridine

Chlorsulfuron (Telar)

Rate 0.75 oz ai/A (1 oz/A)
Time Apply to young, actively growing weeds.
Remarks Do not apply to frozen ground. Maintain constant agitation while mixing product with water. Add 0.25% by volume of nonionic surfactant to spray mixture.
Caution Avoid contact with sensitive crops. Do not treat powdery, dry soils and light, sandy soils if rain is not likely after treatment. Labeled for use on pasture, range, Conservation Reserve Program (CRP), and non-cropland only.
Site of action Group 2: acetolactate synthase (ALS) inhibitor
Chemical family Sulfonylurea

Clopyralid + 2,4-D amine (Curtail)

Rate 1 to 5 quarts/A Curtail
Time Apply to actively growing thistle after most basal leaves emerge but before bud stage.
Remarks Lower rate for in-crop cereal grain application, higher rates for fallow, postharvest, and Conservation Reserve Program (CRP) applications. Consult label for specific directions. With CRP applications, for established grass only. For best results, wait at least 20 days after application before disturbing treated areas (cultivation, mowing, fertilization with shank-type applicators) to allow thorough translocation. Apply in enough total spray volume to ensure good coverage.
Caution See label for crop rotation restrictions before use. Several crops may be injured up to 4 years after application.
Site of action (both) Group 4: synthetic auxin
Chemical family (clopyralid) pyridine; (2,4-D) phenoxy acetic acid

Clopyralid (Stinger or Transline)

Rate 0.09 to 0.375 lb ae/A (0.25 to 1 pint/A). Labeled rates vary with crops.
Time Up to the bud stage of thistles.
Remarks Best if applied to actively growing weeds. See labels for registered sites.
Caution Consult label for crop rotation restrictions before using these products. Several crops may be injured up to 4 years after application.
Site of action Group 4: synthetic auxin
Chemical family Pyridine

Dicamba (Banvel, Rifle, or Clarity)

Rate 0.5 to 1 lb ae/A
Time Apply before flower stalk lengthens on established plants and for seedling control. Spray fall applications to control rosettes.
Remarks Repeat applications for several years to control new seedlings.
Caution Dicamba residues may be in soil for 12 to 18 months after applying. Grass tolerates dicamba at these rates.
Site of action Group 4: synthetic auxin
Chemical family Benzoic acid

Diflufenzopyr + dicamba (Overdrive)

Rate 0.175 to 0.35 lb ae/A (4 to 8 oz/A)
Time Apply to the rosettes.
Remarks Use higher rates on thistles that have bolted. Add a surfactant, either nonionic or methylated seed oil, to the spray mix.
Caution Avoid drift to sensitive crops. Will kill legumes.
Site of action (diflufenzopyr) Group 19: inhibits indole acetic acid transport; (dicamba) Group 4: synthetic auxin
Chemical family (diflufenzopyr) semicarbazone; (dicamba) benzoic acid

Glyphosate + 2,4-D (Campaign)

Rate Broadcast: 16 to 32 fl oz/A. Spot treatment: 1 to 2% solution.
Time Apply to thistles in rosette stage of growth in spring or before freeze-up in fall.
Remarks This product is recommended for musk thistle control in rangeland, pasture, and non-croplands and for the control of those weeds listed on the product label.
Caution Do not graze lactating dairy animals on treated grass within 7 days after application. Animals being finished for slaughter and grazing in the treated area within 30 days of treatment must be removed from the treated area 3 days before slaughter. Do not cut forage for hay within 30 days of application. No grazing restriction if product is used for spot treatments in less than 10% of the total grazed area.
Site of action (glyphosate) Group 9: inhibits EPSP synthase; (2,4-D) Group 4: synthetic auxin
Chemical family (glyphosate) none generally accepted; (2,4-D) phenoxy acetic acid

Metsulfuron (Escort and others)

Rate Escort: 0.6 oz ai/A (1 oz/A)
Time Apply postemergence to actively growing plants.
Remarks Using a nonionic or silicone surfactant increases effectiveness. Certain biotypes of musk and Scotch thistle are more sensitive than others to metsulfuron. Application sites differ between products; consult labels.
Caution Apply only to pasture, rangeland, and non-crop sites.
Site of action Group 2: acetolactate synthase (ALS) inhibitor
Chemical family Sulfonylurea

Picloram (Tordon)

Rate 0.25 lb ae/A
Time Apply in the fall before thistle bolts.
Remarks Do not use on diversified cropland. Follow-up applications will be necessary to control new seedlings and escaped plants.
Caution Most formulations are restricted-use herbicides. Soil residuals may last over 1 years after a 0.25 lb ai/A application. Do not contaminate water. Potatoes, beans, and many other broadleaf crops are sensitive to picloram. Do not use in diversified cropping areas.
Site of action Group 4: synthetic auxin
Chemical family Pyridine

Triclopyr + clopyralid (Redeem R&P)

Rate 1.5 to 2 pints/A

Time Apply to actively growing thistle from rosette to early bolt stage.

Remarks Add a nonionic surfactant at surfactant manufacturer's recommended rate. Apply in at least 10 gal/A water by ground.

Caution Do not exceed 4 pints/A per year. Do not allow drift to desirable vegetation. Note label restrictions on overseeding or reseeding.

Site of action (both) Group 4: synthetic auxin

Chemical family (both) pyridine

SCOTCH BROOM

Spurge Laurel *Daphne laureola*

Other common names: daphne, daphne-spurge, daphne-laurel

Description: Spurge laurel is an attractive ornamental plant known for its spiraling evergreen leaves and greenish-yellow, bitter-fragrant flowers. Larger patches of this species emit a strong unpleasant odor. Flowering occurs in late winter-early spring, producing clusters of blue berries during the spring. The one-seeded drupes are eaten and dispersed widely by birds and small mammals. Shrubs reach a height of 0.5-1.5 meters. They can be either upright or arch over to a more sprawling form. This weed tolerates low light levels from partial to deep shade. It prefers better-drained clay loams and forest loams with neutral to acidic soils. Escaped populations form dense stands mostly under tree canopies. High plant densities produce an abundance of short-lived seeds most of which germinate within 2 years. Young plants will flower and reproduce in the second year under good conditions. Birds are the primary dispersal mechanism.

Impacts: Escaped populations from ornamental plantings continue to expand into forested areas especially adjacent to urban areas. As birds further disperse seeds, more habitats will be invaded and native plant communities altered. Oak woodland forests are the greatest at-risk forests because of this and other aggressive weed species in addition to land clearing activities.

It is no longer a plant of any commercial value. Most plant parts are toxic to humans and contain toxic compounds tigliane diterpenes and coumaris glycosides. Contact with the sap can cause skin irritation and ingestion of the seeds can create poisoning especially in small children.

Introduction: The Daphne family consists of 500 species mostly small shrubs or occasional herbs. Most members of the group produce stem fibers and a few are used for papermaking in Asia. Spurge laurel was planted throughout the Pacific Northwest for decades. It is a native to much of Western Europe and the southern countries of Eastern Europe.

NOTE: When herbicides are used, it is the applicator's legal responsibility to read and follow directions on the product label. Not following label directions, even if they conflict with information provided herein, is a violation of federal law.

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USE PESTICIDES WISELY: ALWAYS READ THE ENTIRE PESTICIDE LABEL CAREFULLY, FOLLOW ALL MIXING AND APPLICATION INSTRUCTIONS AND WEAR ALL RECOMMENDED PERSONAL PROTECTIVE GEAR AND CLOTHING. CONTACT YOUR STATE DEPARTMENT OF AGRICULTURE FOR ANY ADDITIONAL PESTICIDE USE REQUIREMENTS, RESTRICTIONS OR RECOMMENDATIONS.

NOTICE: MENTION OF PESTICIDE PRODUCTS IN THIS COURSE DOES NOT CONSTITUTE ENDORSEMENT OF ANY MATERIAL.

Spurge, Leafy *Euphorbia esula*

Other common names: Wolf's milk, Faitour's grass, Hungarian spurge
Description: Leafy spurge is an aggressive perennial herb that grows upright, branching, and reaches two-three feet tall with tough woody stems that exclude milky white latex sap when broken. It has alternate narrow leaves, somewhat frosted and slightly wavy along the margins. The flower of this weed are very small and are borne in greenish-yellow structures surrounded by yellow distinctive heart-shaped bracts. Leafy spurge has an extensive root system that can extend up to 20 feet below the surface. Rhizomes are woody, brown, have numerous pink buds and are capable of producing above ground shoots. Seeds are ovid to cylindrical and gray to brown in color. Seed capsules have 3 compartments each with 1 seed. Plants are capable of producing copious amounts of seed which is dispersed by an explosive rupturing that can propel seeds up to 10 feet from the plant. All parts of this plant contain a poisonous latex sap.

Impacts: Leafy spurge is one of the West's most invasive and difficult to control weed species. It is capable of invading disturbed sites, including prairies, savannas, pastures, abandoned fields and roadside areas. Like all spurges it is considered toxic to cattle but sheep and goats may readily feed on it following an acclimation period. This plant has the ability to reduce cattle carrying capacity of infested rangelands by 50 to 75%. Leafy spurge is very capable of dominating the plant community and habitat and significantly decreasing the diversity of native species. Leafy spurge also shows allelopathic tendencies. Once established, control of even modest-sized infestations is difficult, and annual treatments are required to contain populations. A grazing prescription which includes sheep grazing prior to other livestock has been successful in increasing agricultural productivity in rangelands infested with leafy spurge in parts of the West. This weed tolerates moist to dry soil conditions but is most common under dry conditions with coarse-textured soils where competition from native plants is reduced. A milky latex exists in all parts of the plant that can cause skin irritations in humans, cattle, and horses and may cause permanent blindness if rubbed into the eye.

Introduction: The scientific name of leafy spurge (Euphorbia esula) can be literally translated from the Greek to mean "good pasture for eating." Sources indicate that name was given to the plant by the King of Mauritania, naming it after his physician Euphorbos for his use of the plant. Native to Europe and Asia, brought to the U. S. from Eurasia about 1897 and it now occurs across much of the northern states.

USE PESTICIDES WISELY: ALWAYS READ THE ENTIRE PESTICIDE LABEL CAREFULLY, FOLLOW ALL MIXING AND APPLICATION INSTRUCTIONS AND WEAR ALL RECOMMENDED PERSONAL PROTECTIVE GEAR AND CLOTHING. CONTACT YOUR STATE DEPARTMENT OF AGRICULTURE FOR ANY ADDITIONAL PESTICIDE USE REQUIREMENTS, RESTRICTIONS OR RECOMMENDATIONS.

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Spurge, Myrtle *Euphorbia myrsinites*

Other common names: Creeping spurge and donkey tail spurge

Description: Perennial; blooms in early spring . Grows 4 to 6 inches tall. Leaves alternately arranged in close spirals around the fleshy, trailing, blue-green stems. Flowers inconspicuous and surrounded by a showy yellow green bract. This plant prefers well-drained dry to moist soils with partial shade to full sun. Myrtle spurge is an escaped ornamental that inhabits disrupted areas and waste places. It grows well in zones 5-9 and is known to like dry rocky areas as well.

Impacts: Originally planted as a rock garden ornamental, the species has escaped and is spreading on to open lands in dryer parts of the state. Seeds can be ejected when plants are disturbed, sticking to wildlife hair and enabling transport far from the parent plants. Aside from displacing desirable native species, the plant invades playgrounds and parks in some states. The sap of myrtle spurge is caustic and creates rashes, swelling and blistering of the skin and is a human health concern.

Suggested Chemical Control Management

2,4-D LV ester

Rate 1 lb ae/A helps prevent seed formation; 6 lb ae/A helps control leafy spurge infestations.
Time Use lower rates to prevent seed formation in the bud to early bloom stage. Use higher rates in early spring applications.
Remarks When mowing is possible, spray 2,4-D on new regrowth 2 week after mowing. Re-treatments will be necessary.
Caution Avoid drift to sensitive crops.
Site of action Group 4: synthetic auxin
Chemical family Phenoxy acetic acid

Aminocyclopyrachlor + chlorsulfuron (Perspective)

Rate 1.8 to 3.2 oz/A aminocyclopyrachlor + 0.7 to 1.3 oz/A chlorsulfuron (4.5 to 8 oz/A of product)
Time Apply to actively growing plants in spring.
Remarks Adjuvants can be used; these include methylated seed oils 0.5 to 1% v/v, nonionic surfactants at 0.25 to 1% v/v, and crop oil concentrates at 1% v/v. Can be applied using an invert emulsion rather than water.
Caution Even low rates can kill nontarget tree and shrub species, so avoid application within a distance equal to the tree height of the sensitive species. Do not allow spray to drift off target. Can injure several grass species including bromes, as well as basin wildrye.
Site of action Group 4 synthetic auxin (aminocyclopyrachlor) Group 2: ALS inhibitor (chlorsulfuron)
Chemical family Phenoxy acetic acid (aminocyclopyrachlor); sulfonylurea (chlorsulfuron)

Dicamba (Banvel, Rifle, or Clarity)

Rate 4 to 8 lb ae/A
Time Apply in spring or early summer.
Remarks Dicamba is both soil- and foliar-active. Use on non-cropland only at these application rates. Repeat each year as needed.
Caution Do not graze livestock in treated fields within 30 days of slaughter.
Site of action Group 4: synthetic auxin
Chemical family Benzoic acid

Fosamine (Krenite S)

Rate 2 gal product/100 gal water
Time Apply at flowering to actively growing plants. Apply spray to wet.
Remarks Will not kill grasses and can be used next to water. Effectiveness may be reduced if rain falls on the same day.
Caution Non-cropland use only.
Site of action Not well understood **Chemical family** Organophosphorus

Glyphosate

Rate 0.38 to 0.75 lb ae/A
Time Applications must be split, at 30-day intervals. For the 0.38 lb ae/A (1 pint) rate, apply 1 pint of glyphosate about June 1, July 1, and August 1. For the 0.75 lb ae/A (2 pints) rate, apply 2 pints of glyphosate about June 1 and July 1.
Remarks Three split applications (0.38 lb ae/A each) are somewhat selective, leaving some perennial grasses. These treatments are suggested when water is near the infested area or when a reseeding of grasses is planned. Applications prevent vegetative growth the year of application and will prevent seed production the second year.
Caution Re-treatment is necessary for continued control. Glyphosate is not selective.
Site of action Group 9: inhibits EPSP synthase
Chemical family None generally accepted

Glyphosate + 2,4-D (Landmaster BW)

Rate 54 oz/A Landmaster
Time Late summer or fall.
Remarks Apply in 3 to 10 gal of water.
Caution Glyphosate is not selective; desirable grasses will be killed at this rate.
Site of action (glyphosate) Group 9: inhibits EPSP synthase; (2,4-D) Group 4: synthetic auxin
Chemical family (glyphosate) none generally accepted; (2,4-D) phenoxy acetic acid

Imazapic (Plateau)

Rate 0.125 to 0.188 lb ai/A
Time Apply in late summer or fall (mid-August through October) before spurge loses its milky sap due to drought or a killing frost.
Remarks Add 1 quart/A methylated seed oil.
Caution Before using, note crop rotation restrictions.
Site of action Group 2: acetolactate synthase (ALS) inhibitor
Chemical family Imidazolinone

Picloram (Tordon)

Rate 0.5 to 1 lb ae/A. Use higher rates in areas that are difficult to re-treat. Make a series of applications of 0.5 lb ae/A if leafy spurge is near running water or lakes.
Time Apply any time in the growing season. Re-treatments needed for several years to control seedlings.
Remarks Picloram has given excellent control with follow-up treatments. It can persist for 2 years at higher application rates.
Caution Most formulations are restricted-use herbicides. Do not contaminate water. Potatoes, beans, and many other broadleaf crops are sensitive to picloram. Do not use in diversified crop areas.
Site of action Group 4: synthetic auxin
Chemical family Pyridine

NOTE: When herbicides are used, it is the applicator's legal responsibility to read and follow directions on the product label. Not following label directions, even if they conflict with information provided herein, is a violation of federal law.

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St. Johnswort *Hypericum perforatum*

ST. JOHNSWORT

Other common names: Klamath weed, goat weed, common St. Johnswort

Description: Perennial; blooms June to July. Grows 1 to 3 ft. tall. Stems erect, numerous branched, somewhat 2 ridged, rust-colored and woody at their base. Leaves opposite, oblong, not over 1 in long and covered in transparent dots. Flowers 3/4 inch in diameter, bright yellow, numerous in flat-topped cymes with five petals with occasional small black dots around the edges. Stamens numerous, arranged in three groups.

Impacts: This difficult to control pest is found throughout most of the western U.S. It invades pasture and rangeland and is poisonous to livestock. Livestock seldom eat the plant unless pasture is scarce. It can invade rangelands to open timber. Infestations spread rapidly on disturbed, well drained sites such as roadways, trails, overgrazed range, and logged areas.

Known hazards: The plant contains a toxic compound that causes photo-sensitivity; poisoning appears to be cumulative. Light pigmented animals develop blisters and scabs on the mouth eyes, ears, nose and feet, especially when exposed to sunlight. Dark colored animals are generally less susceptible.

Family: St. Johnswort Family (Hypericaceae)
Origin and Distribution: Common St. Johnswort is a European native that colonists brought with them when they immigrated to North America. It is now naturalized throughout the eastern half and the west coast of the United States. The species grows in open areas such as pastures, open woods, roadsides, parking lots, and waste areas. It also appears in such disturbed sites as tree plantations, orchards, and agronomic fields that are not regularly cultivated. Common St. Johnswort grows best in sandy soil but it is also found in heavy soils. It usually occurs in dry habitats.

Plant Description: Common St. Johnswort is a perennial weed that has the general appearance of a shrubby herb with many woody stems covered with narrow leaves. It can be distinguished from other herbaceous shrubs by clear dots on its leaves that look like pin holes if the leaf is held up to a light. To distinguish it from other closely related species, look for yellow flowers with petals that are about 1/2 inch long and have black dots along the edge. Reproduction is mainly by seeds, but vegetative spread is possible by rhizomes.
Root system - Roots are slender, branched, brown, and very tough. The root system generally consists of a long taproot with shallow roots extending several inches from the crown.
Seedlings & Shoots - Seedlings consist of a slender, purple stem with 2 leaves, which have a powdery surface appearance and are unpleasant to taste.
Stems - Stems are smooth, upright, usually reddish, woody at the base, and grow up to 3 feet tall. Each plant is usually comprised of several stems with numerous branches.
Leaves - Common St. Johnswort leaves are between 1 to 2 inches long, elliptic, and opposite (2 leaves per node). Leaves lack leaf stalks (petioles), so they attach directly to the stem. Leaves are covered with small dots, visible with a hand lens when the leaf is held up to a light, that look like tiny perforations or pin holes.
Flowers - Flowers are less than 1 inch in diameter and have 5 yellow petals with black dots along the edge. About 25 to 100 flowers can be found in a broad clusters at the top of each stem.
Fruits & Seeds - The fruit is a pod with 3 parts, each filled with numerous dark brown seeds. Seeds are 1/16 inch long, cylindrical, dark brown, shiny, and have a pitted surface.

Similar Species: Common St. Johnswort can be distinguished from the more than 15 other *Hypericum* species by its yellow petals that have black dots on their edges.

Biology: Flowers appear in June to September. A single common St. Johnswort plant produces as many as 100,000 seeds per year. Seeds are wind dispersed or, because they have a gelatinous coating that becomes sticky when wet, they may adhere to animals, machinery, and other objects that can disperse them. If buried in soil, seeds survive up to 10 years. Hand pulling, digging, mowing, and fire are generally ineffective control measures. Common St. Johnswort is tolerant of many herbicides. Regular tillage is an effective control measure but it is not suitable for use on rangelands often infested by this weed. In its native Europe, there are nearly 40 known insect predators that help control common St. Johnswort. Studies have shown that some of these insects are useful as biological agents for long term control of common St. Johnswort in North America. Common St. Johnswort was a troublesome weed of pastures on the West Coast until the implementation of such biological control measures.

Toxicity: Although people differ in their sensitivity to the toxin in this weed, contact can cause second degree burns in some individuals. Ingesting common St. Johnswort causes animals to develop sensitivity to sunlight resulting in dermatitis. Symptoms range from redness and blistering of the skin to loss of hair. Animals with light-colored skin are especially sensitive. If enough of the plant is ingested, death may result. Animals generally do not relish common St. Johnswort, but they will eat it if more palatable herbage is not available. Because common St. Johnswort grows into dense patches that crowd out other species, there could be times when this weed is the only available forage in some pastures. Common St. Johnswort retains its toxic properties when dry, so animals can be affected by eating contaminated hay.

Chemical Control Options

2,4-D

Rate 2 lb ae/A in 50 gal of water
Time Apply before any blossoms open, preferably on new seedlings after germination.
Remarks Repeat applications as needed. Klamath beetles are preferred to control large infestations.
Caution Avoid drift to sensitive crops.
Site of action Group 4: synthetic auxin
Chemical family Phenoxy acetic acid

Metsulfuron (Escort and others)

Rate Escort: 0.6 oz ai/A (1 oz/A)
Time Apply after weeds emerge.
Remarks Use a surfactant to increase effectiveness.
Caution Apply only to pasture, rangeland, and non-crop sites. Application sites differ among products; consult labels.
Site of action Group 2: acetolactate synthase (ALS) inhibitor
Chemical family Sulfonylurea

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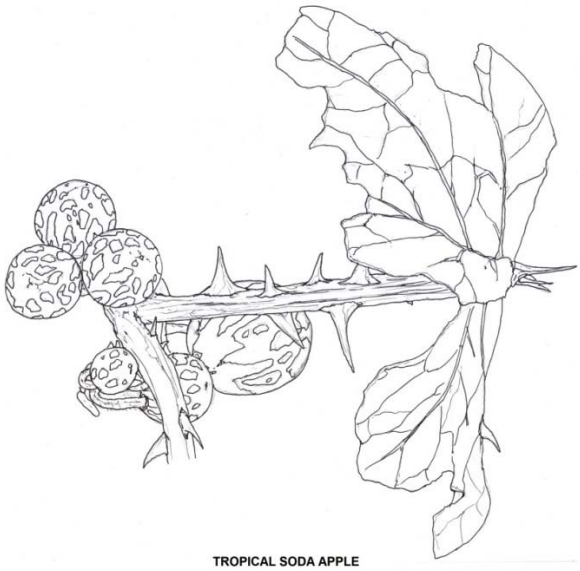
Tropical Soda Apple *Solanum viarum*



TROPICAL SODA APPLE

Nature: Thorny, upright plant with oak-shaped leaves and prolific golf-ball fruit that are mottled green white turning to yellow in late summer to fall. Spreading rapidly in the southern parts of the region with transportation by cattle that have recently ingested fruits and by wildlife feeding of fruits. Viable seed in both green and yellow fruit, but non-viable in white fruit. Consolidates infestations by rootsprouts.
Origin: Native to Argentina and Brazil and introduced into Florida in the 1980's.
Uses: None.

Herbicide Control: Apply Garlon 4 (or Remedy in pastures) or Arsenal AC as 2% solutions in water (8 ounces in a 3-gal. sprayer) or a glyphosate herbicide as a 3% solution in water (12 ounces in a 3-gal. sprayer) with a surfactant to thoroughly wet all leaves and stems at times of flowering before fruit appear. Mowing can be used to stop fruit production and herbicide applications should only be made 50 to 60 days after mowing to allow for adequate regrowth.

Mechanical Methods
Since emerged weeds present at seeding or transplanting are capable of growing rapidly, it is important to kill all weeds prior to planting. Weeds that emerge after planting should be removed early before they are past 3 inches tall. Large weeds are difficult to remove without uprooting vegetable plants. Early season competition which may reduce crop growth, yield, and quality may also occur if weeds are allowed to remain past the 3-inch stage. Removal by hand or cultivation can be used to rid the garden of weeds.

With removal by hand, weeds can be hand pulled or removed using hand tools. Several small hand tools are available that are very effective on small weeds and for working near garden plants. They include the springtooth hand cultivator and the trowel. These tools limit the gardener to working solely on their knees.
There are a variety of effective tools that allow the gardener to stand while removing weeds. They include the scuffle hoe, the Warren hoe, the onion hoe, and the Garden Weasel. Scuffle hoes come in several shapes and are "push-pull" weeders that require no lifting. Perhaps, the most popular is the Dutch version, an open stirrup with a blade. Others consist of triangular plates. Most scuffle hoes are very light weighted and are effective on small weeds. The Warren hoe has an arrowhead shape. It is effective in removing small weeds. It can be used to scratch a furrow with one end and when turned upside down the two shoulder points fill in the furrow. The onion hoe is a thin bladed hoe that is recommended when removing weeds near vegetable plants. It is easier to handle than large, heavy hoes. Onion hoes can be made by simply grinding a common hoe so the blade is thin. This will allow more precise maneuvering near vegetable plants. The Garden Weasel has three sets of wheels with spikes that you "push-pull" to cultivate weeds. It is recommended where numerous small weeds are present. The Garden Weasel is also useful in breaking soil crust to aid vegetable crop emergence.

Whitetop, Hairy *Lepidium pubescens*

HAIRY WHITETOP

Description: Perennial, blooms April-October. Grows up to two feet tall. Leaves three inches long and one inch wide, often smaller. Hairs sparse. Petals white, mostly two to three and one half mm long. Pods strongly inflated, spherical to ovoid, and covered with short hairs. Hairy whitetop is difficult to distinguish from hoary cress in the vegetative state.

Impacts: Hairy whitetop is a common weed species on alkaline soils, but is not restricted to them. It forms dense patches that can completely dominate sites, restricting the growth of other species or degrading pastures. The species is not toxic to livestock but neither is it grazed.

Always follow label instructions and take steps to avoid exposure. If any exposures occur, be sure to follow the First Aid instructions on the product label carefully. For additional treatment advice, contact the Poison Control Center at 1-800-222-1222. If you wish to report a pesticide problem, please call 1-800-858-7378.

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WHITETOP

Whitetop, Lens podded *Cardaria chalapensis*

Description: Lens-podded whitetop is single-stemmed, erect perennial herbs and grows less than knee high. Flowers are generally dense, white and typically flat-topped. Leaves are shaped like a lance, up to four inches long and one inch wide and it clasp the stem and have a heart shaped bases. The infestation of this species is distinguishable by the large white patches in fields.

Impacts: This very invasive weed forms dense patches that can completely dominate meadows and fields, restricting the growth of other species or degrading pastures. The species is not toxic to livestock but neither is it grazed. It negatively affects native fauna as well and very strong competitors for nutrients and moisture. Whitetop is a common weed species on alkaline soils, but is not restricted to them. It has deep, long-lived taproots that store sugars.

Introduction: Lens-podded whitetop is native to central Europe and western Asia. It has now spread to all continents and is particularly common in many parts of North America. Common method of dispersal is through movement of root fragments in mud carried by livestock, vehicles and equipment. Seed dispersal is also commonly spread by hay and forage such as cut alfalfa and by flowing water.

Whitetop *Cardaria draba*

Other common names: Hoary cress

Description: Perennial; blooms early May. Grows up to 2 ft. tall. Deep-rooted. Lower leaves blue-green and lance shaped; upper leaves have two lobes clasping the stem. Many white flowers with four petals, giving plant a white, flat-topped appearance. Three known species, lens-podded, globe-podded, and heart-podded whitetop, identified by different shaped seed pods. Plants usually die back to roots in summer as seeds mature.

Impacts: Whitetop is a common weed species on alkaline soils, but is not restricted to them. It forms dense patches that can completely dominate sites, restricting the growth of other species or degrading pastures. The species is not toxic to livestock but neither is it grazed.

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Yellow Toadflax *Linaria vulgaris*

YELLOW TOADFLAX

Other common names: Butter and eggs

Description: Perennial; blooms summer and fall. Grows 1 to 2 ft. tall. Leaves pale green, narrow and pointed at both ends. Flowers orange and yellow and snapdragon-like.

Impacts: Yellow toadflax is a potential weed problem in zero and minimum till areas because of its prolific seed production and creeping rhizome. It is an aggressive weed in rangeland where it quickly replaces grasses and herbs. It is an alternate host for tobacco mosaic virus. Some sources report that toadflax is poisonous to cattle.

Introduction: Introduced as an ornamental in the United States in the mid-1800's. This invader is still occasionally found in wildflower seed mixes. This plant can be found throughout the U.S.

Family: Snapdragon Family (Scrophulariaceae)

Origin and Distribution: Toadflax is a native of Eurasia that was introduced into North America as a garden flower despite warnings of its weedy potential. Because it was regarded as a desirable wild flower, it was allowed to escape cultivation and spread. As a result, it is now naturalized throughout the U.S. and Canada. Toadflax is commonly found in eastern North America and along the Pacific Coast. It can be found along roadsides, fence lines, waste places, pastures, rangeland, wood edges, and in cultivated fields. Reproduction is by seeds and creeping horizontal roots.

The species is very adaptable and can be found growing in a wide range of conditions from sub-arctic to temperate, dry plateaus to damp rocks, mountain regions to grazed areas, and gravelly or sandy soils to fertile loams.

Plant Description: Toadflax is a perennial with erect, smooth, herbaceous stems that are less than 2 feet tall and emerge in clumps from a spreading root system. Soft, gray-green leaves, which are 1 to 1 1/2 inches long and narrow, are crowded onto each stem.
Stems terminate with clusters of 15 to 20 snapdragon-like flowers that are about 1 inch long and yellow. Gently pinching the sides of a flower opens its 2 lips revealing an orange throat that acts as a guide for insects to nectar produced in the spur. The plant reproduces by seeds and creeping roots.
Root system - The root system consists of horizontal spreading roots and secondary fibrous roots.
Seedlings & Shoots - Young leaves are pale green with a powdery bloom, especially beneath. First true leaves are egg-shaped and the leaves that follow get progressively longer and more linear. Even in young plants, horizontal creeping roots form at the soil surface.
Stems - Stems are erect, leafy, 1 to 2 feet tall, and either hairless or sparsely hairy at the top. Stems may be branched, especially at the top. Multiple stems emerge from the same root system.
Leaves - Leaves are narrow, linear, soft, gray-green, and less than 1 1/2 inches long. Leaves are so densely crowded on the stem that they appear opposite (2 leaves per node) although they are alternate (1 leaf per node). Leaves taper at the base and attach directly to the stem.
Flowers - Flowers consist of 5 united petals forming a 2-lobed upper lip and a lower lip with 3 lobes that end in a long spur. Petals are yellow with an orange palate on the lower lip. Flowers look snapdragon-like and are about 1 inch long. Flowers are located at the top of stems in dense clusters of between 15 to 20.
Fruits & Seeds - Fruits are egg-shaped, 2-celled capsules filled with many blackish, disk-shaped, winged seeds. When dry, pores at the apex of each capsule open releasing seeds.

Similar Species: Dalmatian toadflax (*Linaria dalmatica*) is a related species that is more prevalent in the western portion of North America while toadflax is more common in the east. Compared with toadflax, Dalmatian toadflax is taller, more branched, and has broader leaves with rounded bases that clasp the stem. Also, its seeds are sharply angular rather than round and flat.

Biology: Toadflax flowers from June to August. Seeds are shed from July until frost. Most seeds fall near the parent plant, although seeds have broad wings making wind dispersal possible. Other agents of dispersal include water, insects, and animals. Toadflax reproduces by creeping roots, which results in clumps of individuals sharing the same root system. The plant can usually be controlled by intensive cultivation. Herbicides are also effective, especially if applied when flowering begins in summer. Populations resistant to some herbicides have been reported. Therefore, herbicides should not be used as a sole long-term agent of control. Biological control programs are currently being studied that use insect predators of flowers, fruits, and seeds.

Toxicity: None known.

Chemical Control Options
Chlorsulfuron (Telar)
Idaho and Washington only

Rate 1.5 to 2.25 oz ai/A (2 to 3 oz/A Telar)
Time Apply to actively growing yellow toadflax in the bud to bloom stage.
Remarks Suppresses yellow toadflax. Selective to grasses. Use a penetrating surfactant. Spray to wet.
Caution Do not let spray drift onto sensitive crops. Apply only to non-cropland.
Site of action Group 2: acetolactate synthase (ALS) inhibitor
Chemical family Sulfonylurea

Dicamba (Banvel, Rifle, or Clarity)

Rate 4 to 6 lb ae/A
Time Apply in early spring before toadflax reaches bloom stage.
Remarks Repeated applications may be necessary for complete control.
Caution Avoid drift to sensitive crops. Dicamba severely injures or kills most broadleaf plants.
Site of action Group 4: synthetic auxin
Chemical family Benzoic acid

Imazapic (Plateau)

Rate 0.188 lb ai/A
Time Apply in the fall when top 25% of plant is necrotic, usually after a hard frost.
Remarks Add 1 quart/A methylated seed oil to the spray mix.
Caution Before using, note crop rotation restrictions.
Site of action Group 2: acetolactate synthase (ALS) inhibitor
Chemical family Imidazolinone

Picloram (Tordon)

Rate 1 lb ae/A
Time Apply to actively growing toadflax in spring before full bloom or in late summer or fall.
Remarks A selective treatment that will not damage perennial grasses at the suggested rate.
Caution Most formulations are restricted-use herbicides. Do not contaminate water. Do not use in diversified crop areas. Potatoes, beans, and most other broadleaf crops are sensitive to picloram. This rate for spot treatment only.
Site of action Group 4: synthetic auxin
Chemical family Pyridine

Picloram (Tordon 22K) + 2,4-D

Rate 0.5 lb ae/A picloram + 1.5 lb ae/A 2,4-D
Time In spring before full bloom.
Remarks May require annual treatment for 2 to 3 years. This rate of Tordon 22K may be broadcast.
Caution Tordon is a restricted-use herbicide. See label for grazing restrictions. If rate exceeds 0.5 lb ae/A (1 quart/A), apply only as a spot treatment not to exceed 25% of a landowner's acreage in any particular watershed in a single season. Avoid drift to sensitive crops. Do not contaminate water. Potatoes, beans, and many other broadleaf crops are sensitive to these herbicides. Do not use picloram in diversified crop areas.
Site of action (both) Group 4: synthetic auxin
Chemical family (picloram) pyridine; (2,4-D) phenoxy acetic acid

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Related Information:

- ✓ '*Linaria*' was derived from the Latin 'linon' or 'linum', which means flax, because the foliage looks similar to that of flax.
- ✓ 'Toadflax' refers to the resemblance of the flowers to toads and the foliage to flax.
- ✓ 'Butter-and-eggs' refers to the yellow and orange color of the flowers.
- ✓ Toadflax has been used medicinally to treat various ailments. Teas and lotions made from the foliage were used to treat such complaints as constipation, jaundice, insect bites, and throat problems.
- ✓ Toadflax was widely used to make yellow dye.
- ✓ According to Scottish superstition, walking around toadflax 3 times will unbind any spell, and the English believed that 3 toadflax seeds strung on linen thread would ward off evil.

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Alien Plant Section

Alien plants, also known as exotic, non-native, or non-indigenous plants, are species intentionally or accidentally introduced by human activity into a region in which they did not evolve. Many alien species are well known and economically important in agriculture and horticulture, such as wheat, soybeans, and tulips. Alien species, whether plant or animal, often do not become established outside of cultivation and, if they do, they usually have few impacts on natural communities.

Invasive alien plants, however, escape cultivation and become agricultural pests, infest lawns as weeds, displace native plant species, reduce wildlife habitat, and alter ecosystem processes.

Across the country and around the world, invasive alien plants and animals have become one of the most serious threats to native species, natural communities, and ecosystem processes. They also exact a costly toll from human economies that depend on resources and services provided by healthy ecosystems. Examples include destruction of vast areas of western rangelands, clogging of important waterways, and increased costs in maintaining open powerline rights-of-way.

Of the 4,000 alien plant species introduced to the United States that have escaped cultivation, approximately 400 are serious invaders. Half of this total were introduced for horticultural uses.

Others arrived accidentally in seed mixes, packaging materials, ships ballast, and by other means. Invasive plants now infest more than 100 million acres. One study estimated that from 1901 to 1991, economic losses in the U.S. caused by 15 invasive plant species (not including agricultural weeds) were $603 million (Office of Technology Assessment, 1993).

Once thought to be a problem only on farms or in lawns, invasive plants are now recognized as a threat to natural areas, parks, forests, and other sites in a more or less natural state. Land managers, weed scientists, foresters, ecologists, and other conservationists are joining together to face this challenge in ways that help conserve native species and natural communities and protect environmental quality.

Invasive alien plants typically exhibit the following characteristics:

- Rapid growth and maturity
- Prolific seed production
- Highly successful seed dispersal, germination and colonization
- Rampant vegetative spread
- Ability to out-compete native species
- High cost to remove or control

An invasive plant infestation is like a slow motion explosion, which, if left unchecked, may severely alter a site's natural, economic, aesthetic, and other cultural values. Management of invasive species while maintaining these values can appear to be a complicated and unending task.

For this reason, planning and prioritizing are crucial. By articulating clear goals, gathering the best available information, and prioritizing actions based on the significance of an infestation's impacts and feasibility of control, land managers can identify how their time, effort, and money can most effectively be applied. Invasive species present a difficult challenge with no quick and easy solutions. Many unknowns exist regarding control methods and their efficacy, in addition to limited budgets for managing invasive plants. Sometimes, the best course of action may be to do nothing.

Common Alien Plants which are used as Herbs

Goutweed (*Aegopodium podagraria*)
Garlic mustard (*Alliaria petiolata*)
Giant reed (*Arundo donax*)
Musk thistle (*Carduus nutans*)
Asiatic sand sedge (*Carex kobomugi*)
Spotted knapweed (*Centaurea biebersteinii*)
Yellow starthistle (*Centaurea solstitialis*)
Canada thistle (*Cirsium arvense*)
Leafy spurge (*Euphorbia esula*)
Cogon grass (*Imperata cylindrica*)
Chinese lespedeza (*Lespedeza cuneata*)
Purple loosestrife (*Lythrum salicaria*)
Japanese stilt grass (*Microstegium vimineum*)
Eurasian watermilfoil (*Myriophyllum spicatum*)
Burma reed (*Neyraudia reynaudiana)*
Fountain grass (*Pennisetum setaceum*)
Japanese knotweed (*Polygonum cuspidatum*)
Lesser celandine (*Ranunculus ficaria*)
Annual bastard-cabbage (*Rapistrum rugosum*)
Common mullein (*Verbascum thapsus*)

Annual bastard-cabbage

Roundup-resistant weeds like horseweed and giant ragweed are forcing farmers to go back to more expensive techniques that they had long ago abandoned. There is a particularly tenacious species of glyphosate-resistant pest called Palmer amaranth, or pigweed, whose resistant form has begun to seriously infesting farms.

Pigweed can grow three inches a day and reach seven feet or more, choking out crops; it is so sturdy that it can damage harvesting equipment. In an attempt to kill the pest before it becomes that big, plow fields and mixing herbicides into the soil.

That threatens to reverse one of the agricultural advances bolstered by the Roundup revolution: minimum-till farming. By combining Roundup and Roundup Ready crops, farmers did not have to plow under the weeds to control them. That reduced erosion, the runoff of chemicals into waterways and the use of fuel for tractors.

Goutweed *Aegopodium podagraria* L.

NATIVE RANGE: Most of Europe and northern Asia, to eastern Siberia

DESCRIPTION: Goutweed, also known as bishop's-weed and snow-on-the-mountain, is an herbaceous perennial plant in the carrot family (Apiaceae, formerly the Umbelliferae). It is one of several species of *Aegopodium*, native to Europe and Asia. Most leaves are basal, with the leafstalk attached to an underground stem, or rhizome. The leaves are divided into three groups of three leaflets, making it "triternate." The leaflets are toothed and sometimes irregularly lobed. Foliage of the "wild" type is medium green in color; a commonly planted variegated form has bluish-green leaves with creamy white edges. Sometimes reversion back to solid green or a mixture of solid green and the lighter variegated pattern occurs within a patch.

Small, white, five-petaled flowers are produced in mid-summer. Flowers are arranged in flat-topped clusters (called compound umbels) and are held above the ground on a leafy stem up to about 3 feet tall. The seeds are small and elongate, similar in size and shape to carrot seeds, and ripen in late summer. In contrast to the dense foliage cover produced by goutweed, flowering shoots are uncommon in densely shaded areas.

The rhizomes of goutweed are long, white, and branching, superficially resembling those of quackgrass (*Elytrigia repens*, also known as *Agropyron repens*). Patches of goutweed typically form a dense canopy and can exclude most other herbaceous vegetation. Because of this, it is often used as a low-maintenance ground cover.

ECOLOGICAL THREAT: Goutweed is an aggressive invasive plant that forms dense patches, displaces native species, and greatly reduces species diversity in the ground layer. Goutweed patches inhibit the establishment of conifers and other native tree species as well.

DISTRIBUTION IN THE UNITED STATES: Goutweed is currently known to occur in twenty-nine states in the mid-Atlantic, Northeast and Northwest and is reported to be invasive in natural areas in Connecticut, Michigan, New Jersey, Pennsylvania, Vermont, and Wisconsin.

HABITAT IN THE UNITED STATES: Goutweed is an ecologically versatile species. It is found in old gardens and flowerbeds, around shrubs and other plantings, and in a variety of other disturbed habitats such as felled forests, abandoned fields, and pastures. In Eurasia, goutweed is primarily a species of deciduous and southern boreal forests, and it expands aggressively in similar habitats in North America. Goutweed appears to do best on moist soil and in light to moderate shade, but is highly shade-tolerant and capable of invading closed-canopy forests.

BACKGROUND: Goutweed was apparently first brought to North America as an ornamental during the early stages of European settlement and was well established in the U.S. by 1863. In parts of Russia, the leaves are sometimes used as a salad ingredient and potherb in the spring.

BIOLOGY & SPREAD: Goutweed is vigorous, rhizomatous perennial that spreads mainly by vegetative means. Patches increase in size through extension of the rhizome system. The flowers are pollinated by a wide variety of insects, including beetles, bees, and especially small flies.

The seeds have no apparent morphological features that would facilitate dispersal. Goutweed seeds require cold stratification to germinate. While established goutweed plants are highly competitive in shaded environments, seedlings generally need recently disturbed soil and rather bright light in order to survive. Goutweed apparently does not form a long-lived seed bank, and the seeds generally germinate the year after ripening. Establishment of goutweed seedlings in the shade is rare. The primary vector for dispersal to new areas is humans. Most goutweed colonies spread to neighboring natural areas from intentional plantings, or by the dumping of yard waste that includes discarded rhizomes.

CURRENT MANAGEMENT APPROACHES: A variety of methods are available for controlling goutweed, depending on the extent of the infestation and the amount of time and labor available. Regardless of the control method used, the patch should be carefully monitored periodically for a few years. New shoots should be dug up and destroyed. Once goutweed control has been achieved, revegetation with native or non-invasive exotic plant materials is recommended. This is particularly important on sites where erosion is a concern or where other invasive species are likely to colonize the site if left alone.

Biological. There are no biological control organisms currently available for *Aegopodium podograria* in North America.

Chemical. Systemic herbicides such as glyphosate (Roundup) that are translocated to the roots and kill the entire plant are most effective for goutweed control. However, glyphosate is non-specific and can damage or kill desirable native plants that are accidentally sprayed in the course of treating the goutweed. Contact herbicides are usually ineffective because goutweed readily leafs out again after defoliation.

Manual. Small patches of goutweed can be eliminated by careful and persistent hand-pulling or digging up of entire plants along with underground stems (rhizomes). Pulled plants can be piled up and allowed to dry for a few days before bagging and disposing of them. Be careful to pick up all rhizomes which, if left behind, can re-root and sprout new plants. For large patches, a team of volunteers or use of herbicide is recommended.

Mechanical. Where appropriate, frequent short mowing may control or slow the spread of goutweed in lawns, along roadsides, and other areas.

Physical. Preventing goutweed from photosynthesizing in early spring (at the time of leaf-out) can control the plant by depleting its carbohydrate reserves. This can be accomplished by covering the patch with black plastic sheeting when the leaves start to emerge from the ground in the spring, and leaving it in place through the summer. A more effective option is to cut all plants once they've fully leafed out, using a mower, scythe, or weed-whacker type machine, and then cover the area with plastic. Covering the plants in mid- or late summer, after they have regained substantial starch reserves, is probably much less effective.

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Garlic Mustard *Alliaria petiolata* [Bieb] Cavara & Grande

NATIVE RANGE: Europe

DESCRIPTION: Garlic mustard is a cool season biennial herb in the mustard family (Brassicaceae) with stalked, triangular to heart-shaped, coarsely toothed leaves that give off an odor of garlic when crushed. First-year plants appear as a rosette of green leaves close to the ground. Rosettes remain green through the winter and develop into mature flowering plants the following spring. Flowering plants of garlic mustard reach from 2 to 3-1/2 feet in height and produce button-like clusters of small white flowers, each with four petals in the shape of a cross.

Recognition of garlic mustard is critical. Several white-flowered native plants, including toothworts (*Dentaria*), sweet cicely (*Osmorhiza claytonii*), and early saxifrage (*Saxifraga virginica*), occur alongside garlic mustard and may be mistaken for it.

Beginning in May (in the mid-Atlantic Coast Plain region), seeds are produced in erect, slender pods and become shiny black when mature. By late June, when most garlic mustard plants have died, they can be recognized only by the erect stalks of dry, pale brown seedpods that remain, and may hold viable seed, through the summer.

ECOLOGICAL THREAT: Garlic mustard poses a severe threat to native plants and animals in forest communities in much of the eastern and Midwestern U.S. Many native wildflowers that complete their life cycles in the springtime (e.g., spring beauty, wild ginger, bloodroot, Dutchman's breeches, hepatica, toothworts, and trilliums) occur in the same habitat as garlic mustard. Once introduced to an area, garlic mustard outcompetes native plants by aggressively monopolizing light, moisture, nutrients, soil and space. Wildlife species that depend on these early plants for their foliage, pollen, nectar, fruits, seeds and roots, are deprived of these essential food sources when garlic mustard replaces them. Humans are also deprived of the vibrant display of beautiful spring wildflowers.

Garlic mustard also poses a threat to one of our rare native insects, the West Virginia white butterfly (*Pieris virginiensis*). Several species of spring wildflowers known as "toothworts" (*Dentaria*), also in the mustard family, are the primary food source for the caterpillar stage of this butterfly. Invasions of garlic mustard are causing local extirpations of the toothworts, and chemicals in garlic mustard appear to be toxic to the eggs of the butterfly, as evidenced by their failure to hatch when laid on garlic mustard plants.

DISTRIBUTION IN THE UNITED STATES: Garlic mustard ranges from eastern Canada, south to Virginia and as far west as Kansas and Nebraska.

HABITAT IN THE UNITED STATES: Garlic mustard frequently occurs in moist, shaded soil of river floodplains, forests, roadsides, edges of woods and trails edges and forest openings. Disturbed areas are most susceptible to rapid invasion and dominance. Though invasive under a wide range of light and soil conditions, garlic mustard is associated with calcareous soils and does not tolerate high acidity. Growing season inundation may limit invasion of garlic mustard to some extent.

BACKGROUND: Garlic mustard was first recorded in the United States about 1868, from Long Island, New York. It was likely introduced by settlers for food or medicinal purposes.

BIOLOGY & SPREAD: After spending the first half of its two-year life cycle as a rosette of leaves, garlic mustard plants develop rapidly the following spring into mature plants that flower, produce seed and die by late June. In the mid-Atlantic Coastal Plain region, seeds are produced in erect, slender, four-sided pods, called siliques, beginning in May. Siliques become tan and papery as they mature and contain shiny black seeds in a row. By late June, most of the leaves have faded away and garlic mustard plants can be recognized only by the dead and dying stalks of dry, pale brown seedpods that may remain and hold viable seed throughout the summer. A single plant can produce thousands of seeds, which scatter as much as several meters from the parent plant. Depending upon conditions, garlic mustard flowers either self-fertilize or are cross-pollinated by a variety of insects. Self-fertilized seed is genetically identical to the parent plant, enhancing its ability to colonize an area. Although water may transport seeds of garlic mustard, they do not float well and are probably not carried far by wind. Long distance dispersal is most likely aided by human activities and wildlife. Additionally, because white-tailed deer prefer native plants to garlic mustard, large deer populations may help to expand it by removing competing native plants and exposing the soil and seedbed through trampling.

CURRENT MANAGEMENT APPROACHES: Because the seeds of garlic can remain viable in the soil for five years or more, effective management requires a long term commitment. The goal is to prevent seed production until the stored seed is exhausted. Hand removal of plants is possible for light infestations and when desirable native species co-occur. Care must be taken to remove the plant with its entire root system because new plants can sprout from root fragments. This is best achieved when the soil is moist, by grasping low and firmly on the plant and tugging gently until the main root loosens from the soil and the entire plant pulls out. Pulled plants should be removed from site if at all possible, especially if flowers are present.

For larger infestations of garlic mustard, or when hand-pulling is not practical, flowering stems can be cut at ground level or within several inches of the ground, to prevent seed production. If stems are cut too high, the plant may produce additional flowers at leaf axils. Once seedpods are present, but before the seeds have matured or scattered, the stalks can be clipped, bagged and removed from the site to help prevent continued buildup of seed stores. This can be done through much of the summer. For very heavy infestations, where the risk to desirable plant species is minimal, application of the systemic herbicide glyphosate (e.g., Roundup) is also effective. Herbicide may be applied at any time of year, including winter (to kill overwintering rosettes), as long as the temperature is above 50°F and rain is not expected for about 8 hours. Extreme care must be taken not to get glyphosate on desirable plants as the product is non-selective and will kill almost any plant it contacts. Spray shields may be used to better direct herbicide and limit non-intentional drift.

Fire has been used to control garlic mustard in some large natural settings, but because burning opens the understory, it can encourage germination of stored seeds and promote growth of emerging garlic mustard seedlings. For this reason, burns must be conducted for three to five consecutive years. Regardless of the control method employed, annual monitoring is necessary for a period of at least five years to ensure that seed stores of garlic mustard have been exhausted.

Researchers are investigating potential biological control agents for garlic mustard which may greatly improve the control of this insidious weed.

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Giant Reed *Arundo donax* L.

NATIVE RANGE: India
DESCRIPTION: Giant reed, also known as wild cane, is a tall, perennial grass that can grow to over 20 feet in height. Its fleshy, creeping rootstocks form compact masses from which tough, fibrous roots emerge that penetrate deeply into the soil. Leaves are elongate, 1-2 inches wide and a foot long. The flowers are borne in 2-foot long, dense, plume-like panicles during August and September.

ECOLOGICAL THREAT: Giant reed chokes riversides and stream channels, crowds out native plants, interferes with flood control, increases fire potential, and reduces habitat for wildlife, including the Least Bell's vireo, a federally endangered bird. The long, fibrous, interconnecting root mats of giant reed form a framework for debris dams behind bridges, culverts, and other structures that lead to damage. It ignites easily and can create intense fires.

Giant reed can float miles downstream where root and stem fragments may take root and initiate new infestations. Due to its rapid growth rate and vegetative reproduction, it is able to quickly invade new areas and form pure stands at the expense of other species. Once established, giant reed has the ability to outcompete and completely suppress native vegetation.

DISTRIBUTION IN THE UNITED STATES: Giant reed is distributed from Arkansas and Texas to California, where it is found throughout the state, and in the east, from Virginia to Kentucky and Missouri and generally southward.

HABITAT IN THE UNITED STATES: Giant reed becomes established in moist places such as ditches, streams, and riverbanks, growing best in well drained soils where abundant moisture is available. It tolerates a wide variety of conditions, including high salinity, and can flourish in many soil types from heavy clays to loose sands.

BACKGROUND: Giant reed was probably first introduced into the United States in Los Angeles, California in the early 1800's. Since then, it has become widely dispersed into all of the subtropical and warm temperate areas of the world, mostly through intentional human introductions. Today, giant reed is widely planted throughout the warmer areas of the United States as an ornamental and in the Southwest, where it is used along ditches for erosion control.
Giant reed has a variety of uses ranging from music to medicine. Primitive pipe organs were made from it and the reeds for woodwind instruments are still made from its culms, for which no satisfactory substitutes are known. It is also used in basketry, for fishing rods, livestock fodder, medicine, and soil erosion control.

BIOLOGY & SPREAD: Reproduction of giant reed is primarily vegetative, through rhizomes which root and sprout readily. Little is known about the importance of sexual reproduction in giant reed, or about its seed viability, dormancy, germination, and seedling establishment. Research on these topics may yield some additional improvements in the management of giant reed.

CURRENT MANAGEMENT APPROACHES: Areas infested with giant reed are best restored through chemical means. Mechanical control (e.g., repeated mowing) may be somewhat effective, but if small fragments of root are left in the soil, they may lead to reestablishment.

Systemic herbicides, such as glyphosate (e.g., Rodeo), may be applied to clumps of giant reed, after flowering, either as a cut stump treatment or as a foliar spray. When applying herbicides in or around water or wetlands, be sure to use products labeled for that purpose to avoid harm to aquatic organisms.

Prescribed burning, either alone or combined with herbicide applications, may be effective if conducted after flowering. Once giant reed has been reduced sufficiently, native plants may be seeded or transplanted at the treated site.

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Musk Thistle *Carduus nutans* L.

NATIVE RANGE: Europe and Asia.
DESCRIPTION: Musk, or nodding thistle, a member of the aster family (Asteraceae), is an aggressive, biennial herb with showy red-purple flowers and painful spiny stems and leaves. Mature plants range in height from 1½ to 6 feet tall, and have multi-branched stems. Leaves are dark green, coarsely lobed, with a smooth waxy surface and a yellowish to white spine at the tip. The large disk-shaped flower heads, containing hundreds of tiny individual flowers, are 1½ to 3½ inches in length and occur at the tips of stems. Flower heads will droop to a 90-degree angle from the stem when mature, hence its alternate name, nodding thistle. Each plant may produce thousands of straw-colored seeds adorned with plume-like bristles.

ECOLOGICAL THREAT: Because musk thistle is unpalatable to wildlife and livestock, selective grazing leads to severe degradation of native meadows and grasslands as wildlife focus their foraging on native plants, giving musk thistle a competitive advantage. Although musk thistle is infrequently found in dense forests, it can colonize areas subjected to natural disturbances such as landslides or frequent flooding. Meadows, prairies, grassy balds, and other open areas are susceptible to invasion.
DISTRIBUTION IN THE UNITED STATES: Musk thistle is found throughout the U.S. except for Maine, Vermont, Florida, Alaska and Hawaii.
HABITAT IN THE UNITED STATES: Musk thistle grows from sea level to about 8,000 ft elevation, in neutral to acidic soils. It invades open natural areas such as meadows, prairies, and grassy balds. It spreads rapidly in areas subjected to frequent natural disturbance events such as landslides and flooding but does not grow well in excessively wet, dry, or shady conditions.
BACKGROUND: A native of western Europe, musk thistle was introduced into the eastern United States in the early 1800s and has a long history as a rangeland pest in the U.S. It was first discovered in Davidson County, Tennessee in 1942 and has been declared a noxious weed in many states, including North Carolina.
BIOLOGY & SPREAD: Musk thistle is usually a biennial, requiring 2 years to complete a reproductive cycle, but may germinate and flower in a single year in warmer climates. Seedlings emerge in mid to late July and develop into a rosette where plants can reach 4 feet in diameter. Plants overwinter in the rosette stage until they begin to bolt in mid-March. During the bolting stage plants form multi-branched stems to a height of 6 feet. The number of seedheads per plant is site-dependent and ranges from about 24 to 56 on favorable sites and 1 to 18 on less favorable sites. Flowers emerge in early May to August and seed dissemination occurs approximately one month after the flowers form. A single flower head may produce 1,200 seeds and a single plant up to 120,000 seeds, which may be windblown for miles. Seed may remain viable in the soil for over ten years, making it a difficult plant to control.

CURRENT MANAGEMENT APPROACHES: Mechanical, biological and chemical methods are some of the effective methods available for control of musk thistle. Hand pulling is most effective on small populations and can be done throughout the year, but is most effective prior to the development of seeds.
Flowers and seedheads should be bagged and disposed of in a landfill to prevent or minimize seed dispersal. Minimizing disturbance to the soil during removal activities will help reduce the chance of germination of seeds stored in the soil.

Two weevils have been introduced from Europe and released in the United States as a biological control for musk thistle, the thistlehead-feeding weevil (*Rhinocyllus conicus*) and the rosette weevil (*Trichosirocalus*

horridus). These weevils have been released in a number of western states with some notable successes achieved. However, recent observations of unintentional and unanticipated impacts of the thistlehead-feeding weevil to native thistles, including some rare species, has raised a red flag about its continued use, at least in the western U.S.

Foliar spraying is effective on established populations of musk thistle. Apply a 2% solution of glyphosate (e.g., Roundup) or triclopyr (e.g., Garlon) and water plus a 0.5% non-ionic surfactant wetting all leaves and stems. Chlorpyralid (e.g. Transline) is effective at a concentration of 0.5% and is selective to Aster, Buckwheat, and Pea families. A low pressure and coarse spray pattern will limit drift and damage to non-target species. Treatments should be applied during the rosette stage or prior to flowering. Glyphosate is a non-selective systemic (i.e., moves through the plant) herbicide that can kill non-target plants that are only partially contacted by spray. Triclopyr is selective to broadleaf species and is a better choice if native grasses are present.

SUGGESTED ALTERNATIVE PLANTS: Although not a popular ornamental in the U.S., suitable native alternatives for musk thistle in the eastern U.S. might include butterfly weed (*Asclepias tuberosa*), Joe-pye weed (*Eupatorium dubium*), black-eyed Susan (*Rudbeckia fulgida*), ironweed (*Vernonia noveboracensis*), wild blue phlox (*Phlox divaricata*) and many others. Many plants native to the West are also available. Check with the native plant society in your state for more suggestions.

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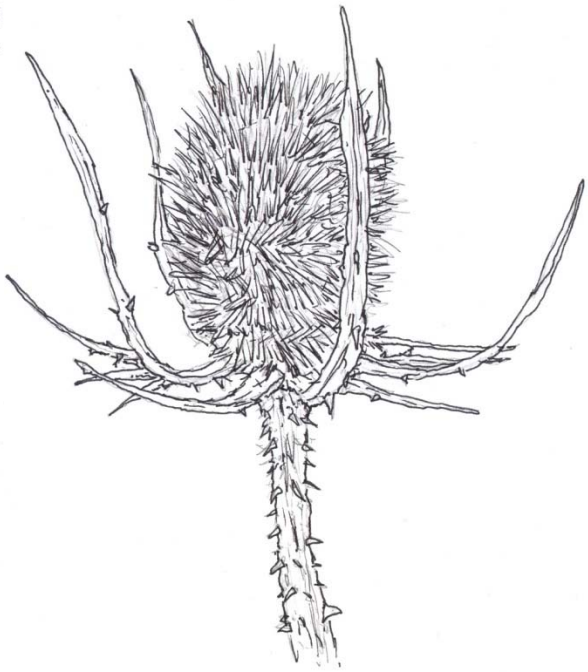
CANADA THISTLE



COMMON TEASEL

Asiatic Sand Sedge *Carex kobomugi* Ohwi

NATIVE RANGE: Coastal areas of northeastern Asia
DESCRIPTION: Asiatic sand sedge is a perennial member of the sedge family (Cyperaceae) adapted to coastal beaches and dunes and possibly the only Carex species found in upper beach habitat along the U.S. Atlantic Coast. The mature sedge is a coarse and stout member of the genus that forms extensive colonies through cord-like rhizomes that extend many feet under the sand and produce new shoots. Flowering and fruiting occurs April through June and individual plants have either male or female flowers. As with many other members of the genus Carex, the flowers are numerous, subtended by scales, and arranged in spikes at the end of a flowering stalk that is triangular in cross section. A papery sac or perigynium encloses the female flowers, each of which develops into a single-seeded fruit, called an achene.

Because flowering culms are evident for a relatively brief period during the spring, and some colonies and new infestations may spread extensively without flowering, it is useful to learn to recognize the plant in its sterile form. Asiatic sand sedge may be confused with at least two colonial, rhizomatous native grass species - American beach grass (*Ammophila breviligulata*) and beach panic grass (*Panicum amarum*). Leaves of Asiatic sand sedge are longer tapering than those of the above grasses, have a yellow-green rather than bluish-green cast, and small teeth along the margin that are easily felt or seen with the help of magnification. These differences become more obvious when observed in the field. Several species of another sedge genus, Cyperus, sometimes grow on dunes and on wash flats and strongly resemble Carex when not in flower. However, these Cyperus species flower from late summer to fall, have leaves without serrated margins, and unlike Asiatic sand sedge, are weakly to non-rhizomatous.

ECOLOGICAL THREAT: Asiatic sand sedge invades wash flat habitat occupied by the federally listed plant, seabeach amaranth (*Amaranthus pumilus*), which is a poor competitor against it. On established, vegetated sand dunes, Asiatic sand sedge can out-compete native dune-binding grasses, like American beach grass and sea oats (*Uniola paniculata*). Dunes dominated by Asiatic sand sedge are also more vulnerable to wind blowouts and storm erosion. There is evidence to suggest that fewer native plant species, and fewer individuals, occur on dunes dominated by Asiatic sand sedge than on comparable dunes dominated by the native American beach grass.

DISTRIBUTION IN THE UNITED STATES: Asiatic sand sedge occurs in maritime areas from Massachusetts to North Carolina [DE, MA, MD, NC, NJ, NY, RI, VA].

HABITAT IN THE UNITED STATES: Asiatic sand sedge grows on primary dunes and on upper parts of ocean beach wash flats that have recently been disturbed by ocean storms. Like American beach grass, it appears to create more habitat for itself by trapping wind-blown sand to form dunes. Sand burial appears to stimulate the growth of rhizomes.

BACKGROUND: Asiatic sand sedge was first observed in the United States, at Island Beach, New Jersey in 1929. Specimens were collected on the Virginia part of the Delmarva (Delaware-Maryland-Virginia) Peninsula as early as the 1940s. Although the circumstances of its introduction are unclear, sand sedge was apparently introduced intentionally for use as a sand binder in erosion-prone areas and may have spread accidentally as a result of its use as a packing material in ship cargo.

BIOLOGY & SPREAD: Once established, Asiatic sand sedge spreads primarily by vegetative means, through production of rhizomes. Sexual reproduction, which requires both male and female plants to be present, is not necessary for a colony to expand locally. Expansion of a colony was observed at Island Beach, New Jersey, despite the absence of any seedlings. Long-distance dispersal of Asiatic sand sedge is uncertain but it is likely that its seeds are tolerant of salt water immersion and carried by ocean currents and storm surges. Plant fragments may be dispersed by ocean currents, and may remain viable after extended salt-water immersion, but this has not been confirmed. Some observation suggests that inundation by storm surges can kill growing plants. In newly forming colonies, sexual reproduction may be somewhat limited, since plants of the opposite sex may not occur nearby. Pollen may be carried long distances by the wind. Much research is needed to gain a better understanding of modes of dispersal and establishment of Asiatic sand sedge.

CURRENT MANAGEMENT APPROACHES: Various mechanical and chemical methods have been used successfully in managing Asiatic sand sedge. Regardless of method, it is important to avoid breaking underground parts and leaving them untreated, and to conduct follow-up monitoring and treatment if needed. Mapping infestations with a Global Positioning System (GPS) prior to treatment is very helpful for relocating sites, especially in sandy natural areas like beaches with few permanent landmarks. Cooperation and coordination among coastal area land managers should lead to more effective control.

Because Asiatic sand sedge is capable of forming extensive colonies, early detection and treatment of infestations is critical for effective management. The potential for considerable long-distance dispersal of seeds necessitates routine monitoring and possible follow up treatments, even after it is believed to be eradicated. Because of the likelihood of leaving viable below-ground parts after an excavation, it is important to revisit the site in subsequent years to ensure that an infestation has been eradicated.

Manual. Excavation of individual plants by digging and hand-pulling is feasible and has been successful when used to control small infestations (e.g., fewer than 200 shoots). This method may not be economically or logistically feasible on larger control projects. Excavation generally involves digging with a shovel under and around each individual plant shoot to expose and loosen the roots. Individual shoots are often connected to other shoots by cordlike rhizomes that are about ¼ inch thick and often of considerable length. Once shoot and roots are loose, all rhizomes need to be gently excavated by hand, following them through the sand to minimize breaking. Rhizome parts left buried are likely to grow into new plants. Because the tips of new tillers (shoots) can be sharp enough to puncture skin, it is important to wear thick gloves when handling below-ground parts. Plants should be removed from the beach and disposed of in habitat unsuitable for the sedge (e.g., lawns), spread out to dry, or composted in black plastic until dead.

Chemical. Larger colonies of Asiatic sand sedge that have formed considerable dunes are probably most effectively controlled using chemical herbicides. A 2% glyphosate (e.g. Roundup, Rodeo, etc.) and water solution applied to the leaves during the growing season has provided effective control. One or two treatments in the same season followed by spot treatments are usually needed. Mid-summer (June through July in Maryland and New Jersey) treatments are just as effective as fall (October in Maryland) applications and allow for same season monitoring and re-treatment. Because rhizomes can be extensive, follow-up monitoring and treatment are necessary for several seasons to ensure long-term control.
Good coverage of herbicide is needed but can be difficult because of the plant's narrow leaves.

To help track application and to minimize misapplication and waste, a colorant can be added to the spray solution. Herbicide applications should be made when the chance of rain is low for at least six hours after application and when winds are minimal (e.g., 0-7 mph), to minimize drift of herbicide to non-target areas. Herbicide users should read and follow all label instructions and, when possible, mix chemicals where a spill containment and/or clean-up facility is available instead of on site. Transport of herbicide is likely to be more rapid through sand than in other soils, and microbial activity that can break down herbicides is likely to be low in beach sand. When it is necessary to mix herbicide on the beach or dunes, it is recommended to mix over a waterproof basin set on top of a waterproof tarp.

SUGGESTED ALTERNATIVE PLANTS: Asiatic sand sedge was originally introduced as a dune stabilizer, although it is apparently less effective in this role than native species, such as American beach grass

(*Ammophila breviligulata*), which occurs throughout the North American range of Asiatic sand sedge. In the southernmost part of this range, sea oats (*Uniola paniculata*) is the dominant native dune binding grass.

Dune Restoration and Planting. Once successful control of Asiatic sand sedge has been achieved, establishing native vegetation is an integral part of dune restoration. Native species such as American beachgrass (*Ammophila breviligulata*) and sea oats (*Uniola paniculata*) should be planted to protect vulnerable dunes from storm damage and blowouts and to prevent re-colonization by Asiatic sand sedge. American beachgrass establishes itself well on primary foredunes where shifting sands are common, and should be planted during late winter to early spring. In primary backdune areas and places where sands are usually more stable, consideration should be given to planting species such as seaside goldenrod (*Solidago sempervirens*), beach panic grass (*Panicum amarum*), dune panic grass (*Panicum amarulum*), and sea-rocket (*Cakile edentula*), in combination with American beachgrass and sea oats.

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BURDOCK

Topic 2 Invasive Plant Species Introduction Post Quiz
Answers at the rear of Glossary

Fill-in-the-blank

What is an Invasive Plant?

1. An invasive plant has the ability to thrive and spread aggressively outside its natural range. A naturally aggressive plant may be especially invasive when it is introduced to a_____.

2. _____was introduced into the U.S in the 1940s and has since spread throughout much of the country. This submersed aquatic plant can form dense mats at the water surface limiting access, recreation, and aesthetics and thus, has decreased the values of shoreline properties in New Hampshire, the Midwest and elsewhere.

Federally Listed Invasive Plant Species

3. _____is easily confused with a closely related species, Russian olive, which is also an invasive species.

4. _____is an aggressive, creeping perennial weed that infests crops, pastures, rangeland, roadsides and non-crop areas. Generally, infestations start on disturbed ground, including ditch banks, overgrazed pastures, tilled fields or abandoned sites. Canada thistle reduces forage consumption in pastures and rangeland because cattle typically will not graze near infestations.

5. _____a native of the Mediterranean region, was introduced to the Americas in 1900 as an ornamental. The pioneers loved this plant because of its lavish, bright yellow flowers and its durability.

6. Japanese knotweed resembles bamboo because of the robust hollow stems with distinct nodes and internodes; however, true bamboo is a grass. The broad and pointed Japanese knotweed leaves can be mistaken for Broadleaf dock (Rumex obtusifolia), but docks lack rhizomes and the tall, spreading habit of Japanese knotweed. Other less invasive relatives (such as P. virginianum) grow from _____and are difficult to eradicate.

7. _____is a creeping, herbaceous perennial weed of foreign origin that reproduces from seed and vegetative root buds. It can reduce rangeland cattle carrying capacity by 50 to 75 percent. About half of this loss is from decreased grass production.

8. _____seeds need loose soil to germinate, and seedlings do best in an open, dry environment. Desirable plants that become established early in the season will create shade that Russian thistle seedlings cannot tolerate.

9. _____is a branched, robust biennial (or sometimes annual) that often grows 8 feet or more in height and 6 feet in width. Main stems may be up to 4 inches wide at the base. Stems have vertical rows of prominent, spiny, ribbon-like leaf material or "wings" that extend to the base of the flower heads. Leaves, which are armed with sharp, yellow spines, are up to 2 feet long and 1 foot wide.

10. _____is an attractive ornamental plant known for its spiraling evergreen leaves and greenish-yellow, bitter-fragrant flowers. Larger patches of this species emit a strong unpleasant odor. Flowering occurs in late winter-early spring, producing clusters of blue berries during the spring.

YELLOW STAR THISTLE
(Centaurea solstitalis)

Topic 3 Commonly Found Invasive and/or Noxious Weeds

Burma Reed *Neyraudia reynaudiana* (Kunth) Keng ex A.S. Hitchc.

NATIVE RANGE: Southeast Asia and Indomalaya (Japan, southern China, Viet Nam, Laos, Cambodia, Thailand, Malaya, Myanmar (Burma), Bhutan, Nepal, and eastern India)

DESCRIPTION: Burma reed, also known as silk reed, cane grass, and false reed, is a tall, perennial, large-plumed grass (Poaceae family) that grows in clumps in sunny upland areas. Stems, including the flower stalks, are from 3 to 15 feet in height, depending on soil and moisture conditions. The leaves are 8 to 10 inches long and hairless, except for a single line of horizontal hairs at the juncture of the upper and lower portions of the leaf.

Stems are approximately ½ inch in width, are round, solid, and have nodes (stem-leaf junctures) every 3 to 5 inches along the stem. The flower plumes, which can be up to 3 feet long, are composed of many hundreds of tiny flowers and have a shimmery, silky appearance. Flowering occurs in April and October, each clump producing an average of forty stalks and twelve to twenty flowering plumes. Burma reed resembles several other tall grasses, including common reed (*Phragmites communis*), giant reed (*Arundo donax*), pampas grass (*Cortaderia selloana*) and sugar cane (*Saccharum officinarum*).

ECOLOGICAL THREAT: Burma reed damages native ecosystems by crowding and shading out understory plant species and by creating conditions for extremely hot and destructive wildfires. In southern Florida (Miami-Dade County), it is a serious threat to the globally imperiled pine rocklands community whose pine canopy was largely destroyed in 1992 by Hurricane Andrew. Burma reed is a highly combustible fuel source because of its overall plant mass, its large feathery flower plumes, and the dense, hay-like leaf litter it produces.

This hay-like litter enhances the fire's movement along the ground, while the flower plumes carry the flames high into the air. With the aid of winds, these plumes often detach and fly through the air like torches, providing the potential for additional spread. Photographs of its ignition during a wildfire show flames leaping over 30 feet high, threatening nearby tree canopies.

DISTRIBUTION IN THE UNITED STATES: Burma reed is found throughout southern Florida in the counties of Miami-Dade, Broward, Palm Beach, Lee, and Collier, and the Florida Keys.

HABITAT IN THE UNITED STATES: In its native range, which is characterized by a warm, subtropical climate, Burma reed occurs in bogs, in open savannahs, on upland cliffs, and along forest and road edges, and thrives from sea level to altitudes of 6,500 feet. In the U.S., Burma reed initially colonizes the margins of roadways, fields, and forests, from which it can spread to undisturbed areas. The ability of Burma reed to survive at high altitudes in its native range indicates a tolerance to cold and the potential for it to spread further north in the U.S.

BACKGROUND: Burma reed was first introduced into the United States in 1916 by the U.S. Department of Agriculture, possibly to investigate its potential as an ornamental plant. It was grown in a test garden in Coconut Grove, Florida, from which it escaped and spread. By 1990, it had become established in the wild as far as 30 miles from Coconut Grove and along disturbed edges throughout Miami-Dade County. Burma reed has no known economic value and, in Bhutan, is reported to be poisonous to buffalo.

BIOLOGY & SPREAD: Burma reed reproduces by seed and through underground stems called rhizomes. Burma reed plants flower twice each year, producing hundreds of thousands of tiny seeds that are dispersed by the wind. New clumps of Burma reed emerge from rhizomes that may be embedded in sand, soil, or rubble. Seeds and rhizomes are also transported inadvertently in limestone rock from infested quarries that is carried by train from Miami-Dade County, Florida to concrete manufacturers throughout the southeastern United States. This unintentional movement of Burma reed material allows it to invade new sites in Florida and adjacent states near limestone distribution centers.

CURRENT MANAGEMENT APPROACHES: Restoration of sites infested with Burma reed requires a long term commitment to ensure effective control and to allow native vegetation to become established. Burma reed's deep roots make mechanical removal an extremely labor intensive and costly undertaking and causes extensive disturbance to the soil. A more effective management approach involves a combination of cutting or prescribed burning, followed by application of herbicides.

After cutting, mowing or burning Burma reed plants down to the ground, a systemic herbicide like glyphosate, mixed with an acidic surfactant (trade name: *ROUNDUP PRO*) can be made to prevent new growth. Repeat treatment is likely to be necessary for a couple of years, until seed and rhizome stores are exhausted.

NOTE: Burning of Burma reed vegetation requires a special permit and should not be undertaken without training, preparation and assistance. Because Burma reed is an extremely flammable plant, fires may quickly get out of hand.

A successful burn of Burma reed reduces the plant’s massive stalks to ash, eliminating the cost of vegetation removal. Conveniently, because Burma reed is the first plant to resprout following a fire, it can be sprayed freely with little concern about non-target kills. It should be noted that burning, by itself, whether through prescribed or natural wildfires, may enhance the growth and spread of Burma reed if not followed up with chemical or mechanical control.

In areas where Burma reed is dispersed among desirable native vegetation, individual plants can be cut at the base using a steel blade (e.g., Weed Wacker) and the remaining portions sprayed with ROUNDUP PRO to prevent new growth. Resprouts should be treated with a second herbicide application to the new growth. This method requires highly qualified applicators who can target the herbicide to avoid damage to native plants, and may not be cost effective for extensive infestations.

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NOTICE: MENTION OF PESTICIDE PRODUCTS IN THIS COURSE DOES NOT CONSTITUTE ENDORSEMENT OF ANY MATERIAL.

Canada Thistle *Cirsium arvense* (L.) Scop.

NATIVE RANGE: Temperate regions of Eurasia
DESCRIPTION: Canada thistle is an herbaceous perennial in the aster family with erect stems 1½-4 feet tall, prickly leaves and an extensive creeping rootstock. Stems are branched, often slightly hairy, and ridged. Leaves are lance-shaped, irregularly lobed with spiny, toothed margins and are borne singly and alternately along the stem. Rose-purple, lavender, or sometimes white flower heads appear from June through October, generally, and occur in rounded, umbrella-shaped clusters.

The small, dry, single-seeded fruits of Canada thistle, called achenes, are 1-1½ inches long and have a feathery structure attached to the seed base. Many native species of thistle occur in the U.S., some of which are rare. Because of the possibility of confusion with native species, Canada thistle should be accurately identified before any control is attempted.

ECOLOGICAL THREAT: Natural communities that are threatened by Canada thistle include non-forested plant communities such as prairies, barrens, savannas, glades, sand dunes, fields and meadows that have been impacted by disturbance. As it establishes itself in an area, Canada thistle crowds out and replaces native plants, changes the structure and species composition of natural plant communities and reduces plant and animal diversity. This highly invasive thistle prevents the coexistence of other plant species through shading, competition for soil resources and possibly through the release of chemical toxins poisonous to other plants.

Canada thistle is declared a "noxious weed" throughout the U.S. and has long been recognized as a major agricultural pest, costing tens of millions of dollars in direct crop losses annually and additional millions in costs for control. Only recently have the harmful impacts of Canada thistle to native species and natural ecosystems received notable attention.

DISTRIBUTION IN THE UNITED STATES: Canada thistle is distributed throughout the northern U.S., from northern California to Maine and southward to Virginia. It is also found in Canada, for which it was named. Canada thistle has been identified as a management problem in many national parks and in preserves of The Nature Conservancy in the upper Midwest, Plains states, and the Pacific Northwest.

HABITAT IN THE UNITED STATES: Canada thistle grows in barrens, glades, meadows, prairies, fields, pastures, and waste places. It does best in disturbed upland areas but also invades wet areas with fluctuating water levels such as streambank sedge meadows and wet prairies.

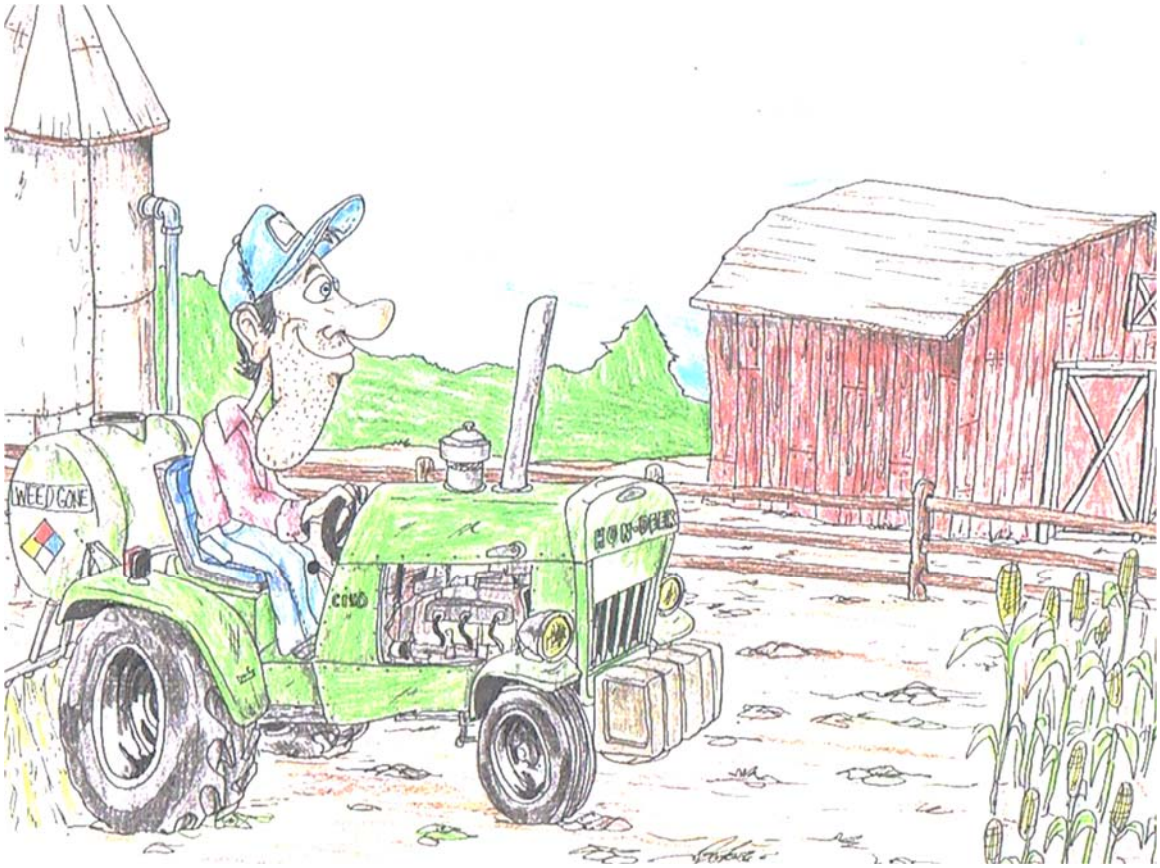
BACKGROUND: Canada thistle was introduced to the United States, probably by accident, in the early 1600s and, by 1954, had been declared a noxious weed in forty three states. In Canada and the U.S., it is considered one of the most tenacious and economically important agricultural weeds, but only in recent years has it been recognized as a problem in natural areas.

BIOLOGY & SPREAD: Canada thistle produces an abundance of bristly-plumed seeds which are easily dispersed by the wind. Most of the seeds germinate within a year, but some may remain viable in the soil for up to twenty years or more.
Vegetative reproduction in Canada thistle is aided by a fibrous taproot capable of sending out lateral roots as deep as 3 feet below ground, and from which shoots sprout up at frequent intervals. It also readily regenerates from root fragments less than an inch in length.

CURRENT MANAGEMENT APPROACHES: Management of Canada thistle can be achieved through hand-cutting, mowing, controlled burning, and chemical means, depending on the level of infestation and the type of area being managed.

Due to its perennial nature, entire plants must be killed in order to prevent regrowth from rootstock. Hand-cutting of individual plants or mowing of larger infestations should be conducted prior to seed set and must be repeated until the starch reserves in the roots are exhausted. Because early season burning of Canada thistle can stimulate its growth and flowering, controlled burns should be carried out late in the growing season for best effects.

In natural areas where Canada thistle is interspersed with desirable native plants, targeted application of a systemic herbicide such as glyphosate (e.g., Roundup or Rodeo), which carries plant toxins to the roots, may be effective. For extensive infestations in disturbed areas with little desirable vegetation, broad application of this type herbicide may be the most effective method. Repeated applications are usually necessary due to the long life of seeds stored in the soil.



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Chinese lespedeza *Lespedeza cuneata* (Dumont) G. Don

NATIVE RANGE: Eastern Asia

DESCRIPTION: Chinese lespedeza is a warm season, perennial herb in the pea family, or Fabaceae. It has an erect growth form, ranging from about 3 to 5½ feet in height, and leaves that alternate along the stem. Each leaf is divided into three smaller leaflets, about ½ to 1 inch long, which are narrowly oblong and pointed, with awl-shaped spines. Leaflets are covered with densely flattened hairs, giving a grayish-green or silvery appearance. Mature stems are somewhat woody and fibrous with sharp, stiff, flattened bristles. Violet to purple flowers emerge either singly or in clusters of 2-4, from the axils of the upper and median leaves.

ECOLOGICAL THREAT: Chinese lespedeza, sometimes called sericea lespedeza, is primarily a threat to open areas such as meadows, prairies, open woodlands, wetland borders and fields. Once it gains a foothold, it can crowd out native plants and develop an extensive seed bank in the soil, ensuring its long residence at a site. Established dense stands of lespedeza suppress native flora and its high tannin content makes it unpalatable to native wildlife as well as livestock.

DISTRIBUTION IN THE UNITED STATES: Chinese lespedeza is now found throughout the U.S.

HABITAT IN THE UNITED STATES: Chinese lespedeza can grow in a variety of habitats including severely eroded sterile soils. It will invade open woodlands, fields, prairies, borders of ponds and swamps, meadows, and open disturbed ground, but is intolerant of shade.

BACKGROUND: Chinese lespedeza is native to eastern Asia and was first introduced in the southern United States. Widespread use of lespedeza by federal and state agencies for bank stabilization, and soil improvement; wildlife, forage and cover; and hay facilitated its spread throughout the eastern United States.

BIOLOGY & SPREAD: Chinese lespedeza begins growth from root crown buds at the base of last year's stem. The flowers begin to develop in late July and continue through October. Within the Lespedeza genus there are no specialized structures for seed dispersal. Dispersal is aided by animals consuming the fruits and passing the seeds. A study on natural populations found that several species of Lespedeza comprise 1.5% to 86.8% of the annual diet of bobwhite quail in the southeastern U.S. Autumn dispersal is aided by the haying of infested fields.

Scarification is necessary for the germination of lespedeza seeds. Mature seeds of this genus remain viable for up to twenty years; one study found a germination rate of 60% after cold storage for 55 years. Seedlings may represent only 1% of the seeds actually available in the soil.

CURRENT MANAGEMENT APPROACHES: Mechanical and chemical methods are the most effective options currently available for Chinese lespedeza. Hand pulling is impractical due to lespedza's extensive perennial root system. Mowing plants in the flower bud stage for two or three consecutive years may reduce the vigor of lespedeza stands and control further spread. Plants should be cut as low to the ground as possible and impact to adjacent native plants should be minimized as much as possible.

Since root reserves increase up to the flower bud stage, all herbicide treatments should be completed in early to mid-summer.

The addition of a non-ionic surfactant at a concentration of 0.5% improves the effectiveness of foliar treatments. Triclopyr and clopyralid have been shown to be effective in controlling Chinese lespedeza.

A 2% solution Triclopyr or 0.5% solution of clopyralid thoroughly mixed with water is effective during the vegetative stage prior to branching or during flowering.

Treatments should cover the leaves and stems of plants to the point of runoff. These herbicides are not labeled for use in wet areas or adjacent to streams. On wet sites a 2% solution of glyphosate is effective from last June until seed set.

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Cogon Grass *Imperata cylindrica* (L.) Palisot

NATIVE RANGE: Southeast Asia, Philippines, China, and Japan

DESCRIPTION: Cogon grass is a perennial, rhizomatous grass that grows from 2 to over 4 feet in height. The leaves are about an inch wide, have a prominent white midrib, and end in a sharp point. Leaf margins are finely toothed and are embedded with silica crystals. The upper surface of the leaf blade is hairy near the base; the undersurface is usually hairless. The flowers are arranged in a silvery, cylindrical, branching structure, or panicle, about 3-11 inches long and 1½ inches wide.

ECOLOGICAL THREAT: Cogon grass can invade and overtake disturbed ecosystems, forming a dense mat of thatch and leaves that makes it nearly impossible for other plants to coexist. Large infestations of cogon grass can alter the normal fire regime of a fire-driven ecosystem by causing more frequent and intense fires that injure or destroy native plants. Cogon grass displaces a large variety of native plant species used by native animals (e.g., insects, mammals, and birds) as forage, host plants and shelter. Some ground-nesting species have also been known to be displaced due to the dense cover that cogon grass creates.

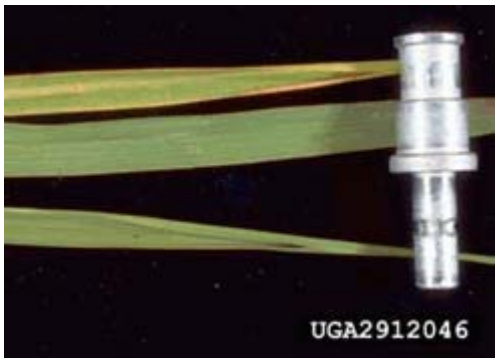
DISTRIBUTION IN THE UNITED STATES: Cogon grass is distributed throughout the south and southeastern United States as far west as eastern Texas. There have been reports of cogon grass surviving as far north as Virginia, West Virginia and Maryland.

HABITAT IN THE UNITED STATES: Cogon grass is a hardy species, tolerant of shade, high salinity and drought. It can be found in virtually any ecosystem, especially those experiencing disturbance. Cogon grass has been found growing on sand dunes in the southeast, along roadsides, forests, open fields, and up to the edge of standing water.

BACKGROUND: Cogon grass was introduced to the United States both accidentally and intentionally. Cogon grass was first introduced to the U.S. in Mobile, Alabama, via shipping crates that contained cogon grass as a packing material. It was also brought in and distributed by the U.S.D.A. for use as a forage grass and for soil erosion control. Cogon grass is also sold by the nursery trade as an ornamental grass, valued for its attractive foliage and hardiness.

BIOLOGY & SPREAD: Cogon grass reproduces both vegetatively and from seed. A single plant can produce several thousand very small seeds that may be carried great distances by the wind. Vegetative spread of cogon grass is aided by its tough and massive rhizomes that may remain dormant for extended periods of time before sprouting. Rhizomes of cogon grass may be transported to new sites in contaminated fill dirt or by equipment used in infested areas.

CURRENT MANAGEMENT APPROACHES: An integrated approach to cogon grass management, including chemical, mechanical and cultural methods, is necessary to achieve successful, long lasting control. Effective management of cogon grass has been achieved by the following combined mechanical-chemical protocol. First, the infested area is mowed in late spring to remove last year's growth and the accumulated thatch layer. About six to eight weeks later, when about eighty percent of the cogon grass has re-sprouted to a height of 6-12 inches, the site needs to be disced as deeply as possible. (Discing may not be possible in all areas, due to the sensitive nature of some ecosystems). When adequate regrowth of the cogon grass has occurred, systemic herbicides (chemicals carried through the plant tissues to the roots) are applied.



The best time to apply herbicides is in the early fall before first frost. A 2% solution of glyphosate (e.g., Roundup) is recommended in areas that will be immediately revegetated, because glyphosate has no residual soil activity. In areas where immediate revegetation is not planned, and non-target plant damage is not a concern, application of a 1-1.5% solution of imazapyr (e.g., Arsenal) may be considered.

IMPORTANT: Because imazapyr is highly active in soil, it has a high potential for leaching into groundwater, so should only be used when groundwater impacts can be eliminated or minimized. Additionally, nearby trees or other plants may be damaged by improper application of this herbicide.

Revegetation may be necessary following herbicide treatment, to prevent soil erosion, and to help reduce re-infestation by cogon grass. For roadside areas, revegetation with Bahia grass and bermuda grass have been used successfully for these purposes. In natural areas, the choice of which species to use for revegetation becomes more difficult. For some areas, assisting the process of natural revegetation succession may be the best choice. Once decisions are made regarding the ultimate goal of the restoration project, revegetation plans should be made accordingly. Regardless of the goal, the area should be revegetated quickly to allow a stable plant community to be established. Lastly, it is important to exercise diligence, as it will be necessary to scout areas that have been treated for cogon grass and spot treat new plants with herbicides.

It may not be possible to use all of the methods prescribed above in every situation, but most effective control will be gained by using as many of the steps outlined above as possible. In areas where burning, mowing, or discing, are not possible, spot treatment with herbicides will help to control cogon grass. Revisit treated areas frequently and retreat with herbicides as necessary. The best time to begin a control program is late spring to mid-summer when cogon grass is experiencing peak growth. Some control measures, such as mowing and spot spraying with herbicides, can be implemented year round. Burning has also been used successfully in controlling cogon grass. As with mowing, burning stimulates the growth and spread of cogon grass, making follow-up control a necessity. If you are interested in attempting this technique, contact management specialists listed below for more specific information. Also, be sure to obtain all required permits before attempting a burn, even on small infestations.

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Common Mullein *Verbascum thapsus* L.

NATIVE RANGE: Europe and Asia
DESCRIPTION: Common mullein, also known as wooly mullein, is an erect herb in the figwort family, or Scrophulariaceae. First year mullein plants are low-growing rosettes of bluish gray-green, felt-like leaves that range from 4-12 inches in length and 1-5 inches in width. Mature flowering plants are produced the second year, and grow to 5 to 10 feet in height, including the conspicuous flowering stalk. The five-petaled yellow flowers are arranged in a leafy spike and bloom a few at a time from June-August. Leaves alternate along the flowering stalks and are much larger toward the base of the plant. The tiny seeds are pitted and rough with wavy ridges and deep grooves and can germinate after lying dormant in the soil for several decades.

ECOLOGICAL THREAT: Common mullein threatens natural meadows and forest openings, where it adapts easily to a wide variety of site conditions. Once established, it grows more vigorously than many native herbs and shrubs, and its growth can overtake a site in fairly short order. Common mullein is a prolific seeder and its seeds last a very long time in the soil. An established population of common mullein can be extremely difficult to eradicate.

DISTRIBUTION IN THE UNITED STATES: Common mullein was first introduced into the U.S. in the mid-1700's, where it was used as a piscicide, or fish poison, in Virginia. It quickly spread throughout the U.S. and is well established throughout the eastern states. Records show that it was first described in Michigan in 1839 and on the Pacific coast in 1876, probably due to multiple introductions as a medicinal herb.

HABITAT IN THE UNITED STATES: Common mullein can be found where mean annual precipitation is greater than 3-6 inches and the growing season lasts for a minimum of 140 days. Intolerant of shade, mullein will grow in almost any open area including natural meadows and forest openings as well as neglected pastures, road cuts, and industrial areas. Common mullein prefers, but is not limited to, dry sandy soils.

BACKGROUND: Common mullein is a monocarpic perennial (i.e., takes two or more years to flower and die). Brought over from Europe by settlers, it was used as a medicinal herb, as a remedy for coughs and diarrhea and a respiratory stimulant for the lungs when smoked. A methanol extract from common mullein has been used as an insecticide for mosquito larvae.

BIOLOGY & SPREAD: During the first summer after germination mullein produces a tap root and a rosette of leaves. During this vegetative stage, the rosette increases in size during the growing season until low temperatures arrest growth sometime during the autumn and winter.

Beginning the next spring, second year plants bolt into maturity, flower, produce seed during the summer, and then die, completing the plant's normal life cycle. Flowers mature from the base to the tip of the stalk. The length of the flowering period is a function of stalk height; longer stalks can continue to flower into early October.

It is estimated that a single plant can produce 100,000-180,000 seeds which may remain viable for more than 100 years. The seeds are dispersed mechanically near the parent plant during the autumn and winter. Seeds at or near the surface are more likely to germinate.

CURRENT MANAGEMENT APPROACHES: Although common mullein can be very difficult to eradicate, there are a variety of management methods available, depending on the particular situation. Because mullein seedling emergence is dependent on the presence of bare ground, sowing sites with early successional native grasses or other plants may decrease seed germination and the chance of successful emergence of mullein seedlings.

Mullein plants are easily hand pulled on loose soils due to relatively shallow tap roots. This is an extremely effective method of reducing populations and seed productivity, especially if plant is pulled before seed set. If blooms or seed capsules are present, reproductive structures should be removed, bagged, and properly disposed of in a sanitary landfill. Care should be taken, however, to minimize soil disturbance since loose soil will facilitate mullein seed germination.

There are two insects that have possible biological control implications for mullein. A European curculionid weevil (*Gymnaetron tetrum*), determined by the U.S. Department of Agriculture to be specific to mullein, has been introduced to North America. The weevil larvae matures in the seed capsules and can destroy up to 50% of the seeds. Another agent, the mullein moth (*Cucullia verbasci*) has been tested in the U.S. and is considered to be a relatively safe control agent because of its consistent feeding and development on mullein species. Although tests showed limited feeding on other native species, the larvae did not survive significantly longer than those individuals tested in the absence of food.

Release of biological controls into natural environments is always experimental and should be entered into only after full and careful consideration of potential non-target species impacts.

Once released into nature, biological control agents are difficult, if not impossible, to control. For situations where hand-pulling of plants is not practical or safe--for example, on very steep slopes where hand pulling is dangerous or would cause significant soil disturbance--herbicidal control is an effective option. Apply a 2% solution of glyphosate (e.g., Roundup) or triclopyr (Garlon) and water plus a non-ionic surfactant, using a tank or backpack sprayer to thoroughly cover all leaves. Do not apply so heavily that the herbicide drips off the leaf surface. Use caution as glyphosate is a non-selective herbicide that may kill desirable plants even if partially contacted by spray. Triclopyr is selective to broadleaf plants and is a better choice if native or other desirable grasses are present. For some sites, applications can be made during the early spring when most other non-target vegetation is dormant. Refer to the pesticide manufacturers' label for specific information and restrictions regarding herbicide use.

For more information on the management of Common Mullein, please contact:
Kris Johnson, Great Smoky Mountains National Park, Gatlinburg, TN (kris_johnson@nps.gov)

SUGGESTED ALTERNATIVE PLANTS: Although not a popular ornamental, there are many excellent native plant alternatives for mullein that thrive in full sun and sandy soils. In the eastern U.S., common milkweed (*Asclepias syriaca*), butterflyweed (*Asclepias tuberosa*), joe-pye weed (*Eupatorium dubium*), black-eyed Susan (*Rudbeckia fulgida*), and Ironweed (*Vernonia noveboracensis*), are just a few of the many selections. You may wish to contact your local native plant society for further suggestions.

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Eurasian Watermilfoil *Myriophyllum spicatum* L.

NATIVE RANGE: Eurasia and Africa

DESCRIPTION: Eurasian watermilfoil, also called spike watermilfoil, is an emergent, herbaceous aquatic plant in the Water-milfoil family, or Haloragaceae. Stems grow to the water surface, usually extending 3 to 10, but as much as 33, feet in length and frequently forming dense mats. Stems of Eurasian milfoil are long, slender, branching, hairless, and become leafless toward the base. New plants may emerge from each node (joint) on a stem, and root upon contact with mud. The grayish-green leaves of Eurasian watermilfoil are finely divided and occur in whorls of three or four along the stem, with 12-16 pairs of fine, thin leaflets about 12 inches long. These leaflets give milfoil a feathery appearance that is a distinguishing feature of the plant. Eurasian watermilfoil produces small yellow, 4-parted flowers on a spike that projects 2-4 inches above the water surface. The fruit is a hard, segmented capsule containing four seeds.

ECOLOGICAL THREAT: Eurasian milfoil can form large, floating mats of vegetation on the surface of lakes, rivers, and other water bodies, preventing light penetration for native aquatic plants and impeding water traffic. The plant thrives in areas that have been subjected to various kinds of natural and manmade disturbance.

DISTRIBUTION IN THE UNITED STATES: Watermilfoil occurs in thirty-three states east of the Mississippi River and has recently been found in Colorado. It is abundant in the Chesapeake Bay, the tidal Potomac River, and several Tennessee Valley reservoirs.

HABITAT IN THE UNITED STATES: Typical habitat for Eurasian watermilfoil includes fresh to brackish water of fish ponds, lakes, slow-moving streams, reservoirs, estuaries, and canals.. It is tolerant of many water pollutants. Eurasian watermilfoil tends to invade disturbed areas where native plants cannot adapt to the alteration. It does not spread rapidly into undisturbed areas where native plants are well established. By altering waterways, humans have created a new and unnatural niche where milfoil thrives.

BACKGROUND: Eurasian watermilfoil was accidentally introduced from Eurasia in the 1940s. Two theories exist as to how it entered North America: (1) it escaped from an aquarium, or (2) it was brought in attached to commercial or private boats. A resort owner is thought to have introduced watermilfoil into the Tennessee Valley Authority reservoir system in 1953.

BIOLOGY & SPREAD: Most regeneration of Eurasian watermilfoil is from rhizomes, fragmented stems, and axillary buds that develop throughout the year. Flower spikes often remain above water until pollination is complete, then re-submerge. Although seeds are usually viable, they are not an important means of dispersal.

CURRENT MANAGEMENT APPROACHES: Large harvesting equipment can be used to mechanically remove milfoil in larger areas; a sturdy hand-rake can be used for smaller areas. Other available options include manipulation of water level, light penetration and chemical control. Potential impacts to existing native aquatic plant species should be evaluated carefully before implementing any of these techniques. For the single harvest, removal should take place just before peak biomass is obtained (early summer). Substantial regrowth may occur if this is done too early. Better results appear with multiple harvests in the same growing season. If multiple harvests are not possible, then sustaining annual harvests is an option. All fragments of milfoil plants must be removed to achieve adequate control.

Where water levels are under manual control, raising or lowering the water level can be an effective way to reduce the growth of milfoil. By raising the water level, plants can be "drowned" by not having access to enough light.

By lowering the water level, plants can be dehydrated and, at the right time of the year, frozen to death. This type of control is best used in conjunction with herbicides and shade barriers.

Bankside plantings, floating native plant species, light limiting dyes, or shade barriers are effective ways of reducing the amount of light reaching the plants, and may reduce overall growth rates. Barriers can be used to prevent the movement and spread of aquatic weeds in ponds and lakes. A barrier is usually a suspended blocking screen that hangs vertically from a cable to a depth of about 4 meters; the cable is suspended by drum floats.

Fluridone (the active ingredient in Sonar AS) is a selective herbicide for milfoil and several other exotic aquatic weeds. There are no restrictions on swimming, fishing, or drinking after application, and season-long control can be achieved with one application. Fluridone is available in liquid or granular form, and can be used as a spot treatment or on an entire waterway. For best results, applications should be made before or during the early stages of active growth.

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NOTICE: MENTION OF PESTICIDE PRODUCTS IN THIS COURSE DOES NOT CONSTITUTE ENDORSEMENT OF ANY MATERIAL.

Fountain Grass *Pennisetum setaceum* (Forsk.) Chiov

NATIVE RANGE: Northern Africa

DESCRIPTION: Fountain grass is an attractive perennial grass with a densely clumped growth form and erect stems that grow 2 to 3 feet high. The small flowers of fountain grass are grouped in pink or purple, bristly, upright inflorescences 6-15 inches long. Fruits are small, dry achenes adorned with long showy bristles.

ECOLOGICAL THREATS POSED BY PLANT: Fountain grass is a highly aggressive, fire-adapted colonizer that readily outcompetes native plants and rapidly reestablishes after burning. In Hawaii, where it alters the natural fire regime, fountain grass is a major threat to some critically imperiled plant species and natural communities. Fountain grass raises fuel loads, which increases the intensity and spread of a fire, and results in severe damage to native, dry forest species adapted to less extreme fire regimes.

DISTRIBUTION IN THE UNITED STATES: Fountain grass is found in Arizona, California, Colorado, Hawaii, Florida, Louisiana, and Tennessee. In the Hawaiian islands, it is found on the islands of Kauai, Oahu, Lanai, and Hawaii.

HABITAT IN THE UNITED STATES: In Hawaii, fountain grass invades many types of natural areas, from bare lava flows to rangelands. It has a wide elevation range but is limited to areas with a median annual rainfall of less than 50 inches. In southern California, fountain grass invades grasslands, deserts, canyons and roadsides.

BACKGROUND: First collected in Hawaii in 1914, fountain grass has been introduced to many parts of the world as an ornamental grass. It is a poor pasture grass and a serious weed in many dry habitats.

BIOLOGY & SPREAD: Fountain grass is a perennial plant with primarily wind-dispersed seeds that may remain viable in the soil for six years or longer. Its seeds may be dispersed greater distances by water, vehicles, livestock and humans.

CURRENT MANAGEMENT APPROACHES: The long-lived seeds of fountain grass make its control extremely difficult. Small infestations may be managed by uprooting plants by hand and destroying the inflorescences in order to prevent seed dispersal. Removal by hand may need to be repeated several times per year. Extensive infestations of fountain grass are probably best controlled with the help of herbicides, especially those with some systemic activity.

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WEED
COP

Japanese Knotweed *Polygonum cuspidatum* Sieb. & Zucc.

NATIVE RANGE: Eastern Asia

DESCRIPTION: Japanese knotweed, a member of the buckwheat family (Polygonaceae), is an upright, shrublike, herbaceous perennial that can grow to over 10 feet in height. As with all members of this family, the base of the stem above each joint is surrounded by a membranous sheath. Stems of Japanese knotweed are smooth, stout and swollen at joints where the leaf meets the stem. Although leaf size may vary, they are normally about 6 inches long by 3 to 4 inches wide, broadly oval to somewhat triangular and pointed at the tip. The minute greenish-white flowers occur in attractive, branched sprays in summer and are followed soon after by small winged fruits. Seeds are triangular, shiny, and very small, about 1/10 inch long.

Japanese knotweed is designated a noxious weed in most states.

ECOLOGICAL THREAT: Japanese knotweed spreads quickly to form dense thickets that exclude native vegetation and greatly alter natural ecosystems. It poses a significant threat to riparian areas, where it can survive severe floods and is able to rapidly colonize scoured shores and islands. Once established, populations are extremely persistent.

DISTRIBUTION IN THE UNITED STATES: Current distribution of Japanese knotweed includes 36 states in the lower 48, from Maine to Wisconsin, south to Louisiana, and scattered Midwest and western states. It is not currently known to occur in Hawaii.

HABITAT IN THE UNITED STATES: Japanese knotweed can tolerate a variety of adverse conditions including full shade, high temperatures, high salinity, and drought. It is found near water sources, such as along streams and rivers, in low-lying areas, waste places, utility rights-of-way, and around old home sites. It can quickly become an invasive pest in natural areas after escaping from cultivated gardens.

BACKGROUND: Japanese knotweed was probably introduced to the U.S. in the late 1800's. Also known as crimson beauty, Mexican bamboo, Japanese fleece flower, or Reynoutria, it was first introduced as an ornamental and has also been used for erosion control and for landscape screening. It is now found throughout the eastern U.S., in several western states, and Alaska, which has few exotic invasive plants to date.

BIOLOGY & SPREAD: Japanese knotweed spreads primarily by vegetative means with the help of its long, stout rhizomes. It is often transported to new sites as a contaminant in fill dirt; seeds are sometimes distributed by water, and carried to a lesser extent by the wind. Escapees from neglected gardens, and discarded cuttings are common routes of dispersal from urban areas.

CURRENT MANAGEMENT APPROACHES: Grubbing is effective for small initial populations or environmentally sensitive areas where herbicides cannot be used. Using a Pulaski or similar digging tool, remove the entire plant including all roots and runners. Juvenile plants can be hand pulled depending on soil conditions and root development. Any portions of the root system not removed will potentially re-sprout. All plant parts (including mature fruit) should be bagged and disposed of in a trash dumpster to prevent re-establishment.

Cut stem treatment: Use this method in areas where plants are established within or around non-target plants or where vines have grown into the canopy. This treatment remains effective at low temperatures as long as the ground is not frozen. Cut the stem about 2 inches above ground level. Immediately apply a 25% solution of glyphosate (e.g., Roundup, or use Rodeo if applying in or near wetland areas) or triclopyr (e.g., Garlon) and water to the cross-section of the stem. A subsequent foliar application of glyphosate may be required to control new seedlings and re-sprouts.

Foliar spray method: Use this method to control large populations. It may be necessary to precede foliar applications with stump treatments to reduce the risk of damaging non-target species. Apply a 2% solution of glyphosate or triclopyr and water to thoroughly wet all foliage. Do not apply so heavily that herbicide will drip off leaves. A 0.5% non-ionic surfactant is recommended in order to penetrate the leaf cuticle, and ambient air temperature should be above 65 ºF.

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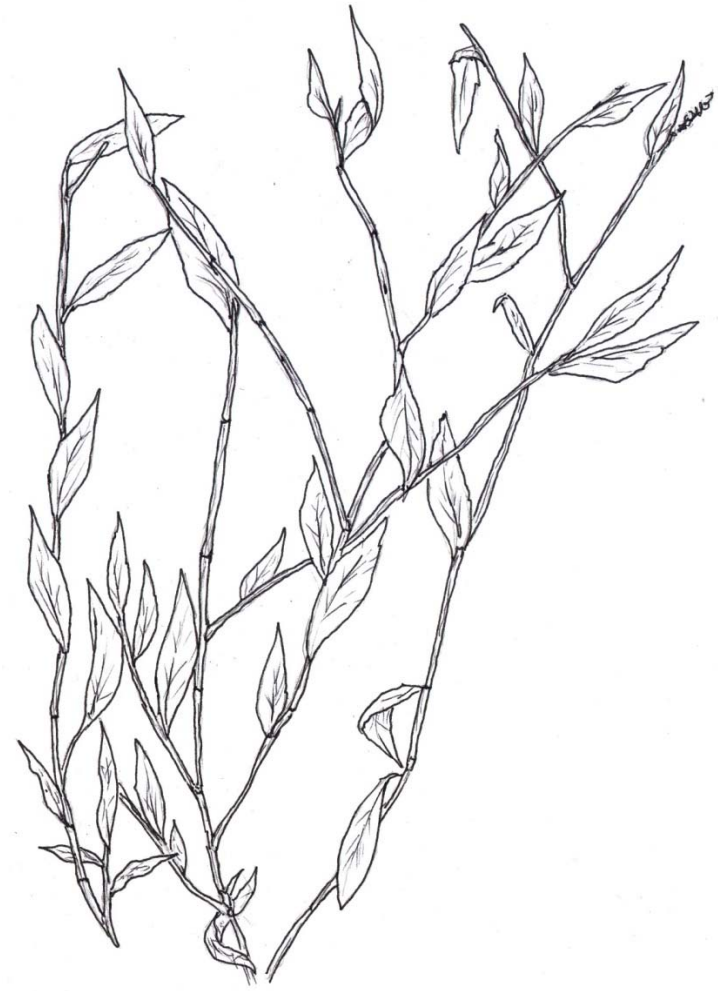
Japanese Stilt Grass *Microstegium vimineum* (Trin.) Camus



JAPANESE STILTGRASS

NATIVE RANGE: Japan, Korea, China, Malaysia, and India

DESCRIPTION: Japanese stilt grass, also known as Asian stilt grass, Vietnamese stilt grass, Nepal microstegium, and Chinese packing grass, is an annual grass (family Poaceae) with a sprawling habit that may grow to 3 feet in height. Its thin, pale green, lance-shaped leaves, about 3 inches in length, alternate along a branched stalk and have a silvery stripe of reflective hairs down the middle of the upper leaf surface. Delicate spikes of flowers emerge from slender tips beginning in late summer and continuing into the fall. Seeds may persist through the fall.

ECOLOGICAL THREAT: Japanese stilt grass is adapted to low light conditions and threatens native understory vegetation in open to shady locations. It spreads opportunistically following soil disturbance to form dense patches, displacing native wetland and forest vegetation as the patch expands.

DISTRIBUTION IN THE UNITED STATES: Japanese stilt grass is currently established in sixteen eastern states, from New York to Florida.

HABITAT IN THE UNITED STATES: Stilt grass occurs on stream banks, river bluffs, floodplains, emergent and forested wetlands, moist woodlands, early successional fields, uplands, thickets, roadside ditches, gas and power line corridors and home lawns and gardens.

It readily invades and is most common in disturbed shaded areas like floodplains that are prone to natural scouring, and areas subject to mowing, tilling and other soil disturbing activities. Japanese stilt grass appears to be associated primarily with moist, acidic to neutral soils that are high in nitrogen. It occurs opportunistically in areas of open soil that are generally not already occupied by other species.

BACKGROUND: Introduced into Tennessee around 1919, Japanese stilt grass may have accidentally escaped as a result of its use as a packing material for porcelain.

BIOLOGY & SPREAD: Japanese stilt grass is a colonial species that spreads by rooting at nodes along the stem. A new plant emerges from each node. It also spreads by seed and each plant can produce an estimated 100-1,000 seeds. Once established at a site, seed stored in the soil will ensure regrowth for several to many years. Studies have shown that stilt grass seed remains viable in the soil for at least three years and germinates readily following soil disturbance. Although seed dispersal of stilt grass is not fully understood, seeds are probably carried by water currents in streamside habitats and floods, and transported widely in hay and soil.

CURRENT MANAGEMENT APPROACHES: Whenever possible, prevent the introduction of Japanese stilt grass from invaded sites into adjacent natural plant communities by avoiding disturbance to vegetation and soil in these areas. Early control of new infestations will also greatly reduce the likelihood of its establishment.

Because it is shallow-rooted, stilt grass may be pulled by hand at any time, but if done early in the summer, disturbance to the soil may allow for germination of stored stilt grass seed. Hand pulling of plants will need to be repeated and continued for many seasons. A more effective mechanical method might be to wait until late summer (September) when the plants are in peak bloom but before seed is produced, and simply cut them back using a mower or "weed whacker". Being an annual plant, Japanese stilt grass cut late in the season will die back for the winter and not produce additional vegetative shoots.

For extensive infestations, where mechanical methods are not feasible, a systemic herbicide like glyphosate (e.g., Roundup), an herbicidal soap that kills the plants back (e.g., Scythe) and herbicides specific to annual grasses may be a more effective choice. If applying glyphosate to stilt grass in wetland sites, use the formulation labeled for wetland areas (e.g., Rodeo). No biological controls are currently available for this plant.

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Leafy Spurge *Euphorbia esula* L.

LEAFY SPURGE

NATIVE RANGE: Europe and Asia
DESCRIPTION: Leafy spurge is a member of the spurge family, or Euphorbiaceae, characterized by plants containing a white milky sap and flower parts in three's. Leafy spurge is an erect, branching, perennial herb 2 to 3½ feet tall, with smooth stems and showy yellow flower bracts.

Stems frequently occur in clusters from a vertical root that can extend many feet underground. The leaves are small, oval to lance-shaped, somewhat frosted and slightly wavy along the margin. The flowers of leafy spurge are very small and are borne in greenish-yellow structures surrounded by yellow bracts. Clusters of these showy, yellow bracts open in late May or early June, while the actual flowers do not develop until mid-June.

ECOLOGICAL THREAT: Leafy spurge displaces native vegetation in prairie habitats and fields through shading and by usurping available water and nutrients and through plant toxins that prevent the growth of other plants underneath it. Leafy spurge is an aggressive invader and, once present, can completely overtake large areas of open land.

DISTRIBUTION IN THE UNITED STATES: Leafy spurge occurs across much of the northern U.S., with the most extensive infestations reported for Montana, North Dakota, Nebraska, South Dakota, and Wyoming. It has been identified as a serious pest in a number of national parks and in preserves of The Nature Conservancy in eleven northern states.

HABITAT IN THE UNITED STATES: Leafy spurge tolerates moist to dry soil conditions but is most aggressive under dry conditions where competition from native plants is reduced. It is capable of invading disturbed sites, including prairies, savannas, pastures, abandoned fields and roadside areas.

BACKGROUND: Leafy spurge was transported to the U.S. possibly as a seed impurity in the early 1800s. First recorded in Massachusetts in 1827, leafy spurge spread quickly and reached North Dakota within about 80 years.

BIOLOGY & SPREAD: Leafy spurge reproduces readily by seeds that have a high germination rate and may remain viable in the soil for at least seven years, enhancing its chances of recovery over time. Its seed capsules open explosively, dispersing seed up to 15 feet from the parent plant and may be carried further by water and wildlife. Leafy spurge also spreads vegetatively at a rate of several feet per year. The root system is complex, can reach 15 or more feet into the ground, and may have numerous buds.

CURRENT MANAGEMENT APPROACHES: Because of its persistent nature and ability to regenerate from small pieces of root, leafy spurge is extremely difficult to eradicate. Biological control offers a highly promising management tactic for leafy spurge. The U.S. Department of Agriculture has shown success using six natural enemies of leafy spurge imported from Europe. These include a stem and root-boring beetle (*Oberea erythrocephala*), four root-mining flea beetles (*Aphthona* spp.) and a shoot-tip gall midge (*Spurgia esulae*). Large scale field-rearing and release programs are carried out cooperatively by federal and State officials in many northern states. The results are not as immediate as when herbicides are used, but if pesticide use is kept to a minimum, large numbers of these agents build up within a few years and have shown impressive results.

Several systemic herbicides have been found to be effective if applied in June, when the flowers and seeds are developing, or in early to mid-September, when the plants are moving nutrients downward into the roots.

Preliminary research suggests that chemical treatment in the fall followed by a spring burn to reduce seed germination may be an effective strategy for reducing leafy spurge infestations.

Multiple treatments are necessary every year for several years, making leafy spurge control an extremely expensive undertaking. If left uncontrolled for a single year, leafy spurge can re-infest rapidly. Prescribed burning, in conjunction with herbicides, may also be effective.

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Lesser Celandine Fig Buttercup *Ranunculus ficaria* L.

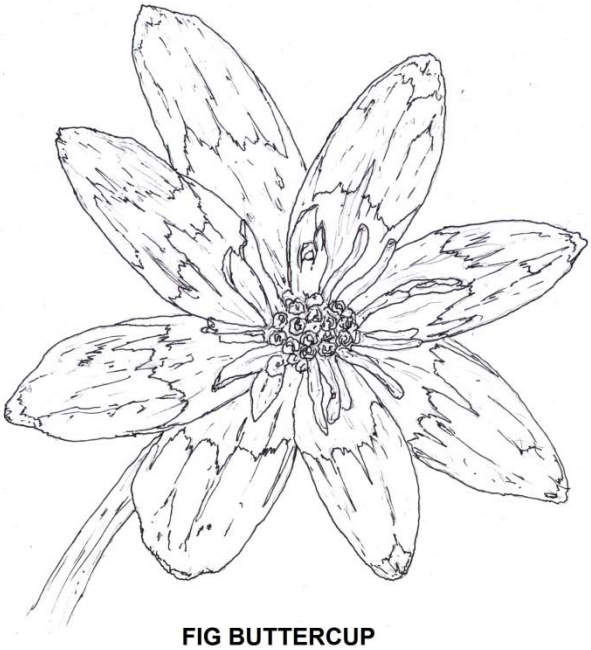

FIG BUTTERCUP

NATIVE RANGE: Europe
DESCRIPTION: Lesser celandine, also known as fig buttercup, is an herbaceous, perennial plant in the buttercup family (Ranunculaceae). Plants have a basal rosette of dark green, shiny, stalked leaves that are kidney- to heart-shaped. The flowers open in March and April, have eight glossy, butter-yellow petals, and are borne singly on delicate stalks that rise above the leaves. Pale-colored bulblets are produced along the stems of the above-ground portions of the plant, but are not apparent until late in the flowering period. When in bloom, large infestations of lesser celandine appear as a green carpet with yellow dots, spreading across the forest floor. There are many varieties of lesser celandine including a double-flowered form with many crowded petals and dark green leaves mottled with silvery markings.

NOTE: Lesser celandine closely resembles marsh marigold (*Caltha palustris*), a native wetland plant that occurs in the eastern United States. Marsh marigold is a robust plant with glossy, rounded or kidney-shaped leaves and flowers on stalks that are 8 in (20.3 cm) or more in height and consist of five to nine deep yellow "petals" (actually sepals). Marsh marigold does not produce tubers or bulblets, nor does it form a continuous carpet of growth. Extreme care should be taken to correctly identify lesser celandine before undertaking any control measures to avoid impacts to this plant.

ECOLOGICAL THREAT: Lesser celandine is an exotic spring ephemeral and a vigorous growing groundcover that forms large, dense patches on the forest floor, displacing and preventing native plants from co-occurring. The ecological impact of lesser celandine is primarily on the native spring-flowering plant community and the various wildlife species associated with them. Spring ephemerals complete the reproductive part of their life cycle and most of their above-ground development before woody plants leaf out and shade the forest floor. Native spring ephemerals include bloodroot, common and cut-leaved toothwort, Dutchman's breeches, harbinger-of-spring, squirrel-corn, trout lily, Virginia bluebells, and many others. Because lesser celandine emerges well in advance of the native species, it can establish and overtake areas rapidly.

DISTRIBUTION IN THE UNITED STATES: Lesser celandine is currently found in nineteen states in the Northeast and Pacific Northwest. It is reported to be invasive in nine states (Connecticut, Delaware, Maryland, New Jersey, Oregon, Pennsylvania, Virginia, Wisconsin, West Virginia), and the District of Columbia.

HABITAT IN THE UNITED STATES: Lesser celandine occurs in moist forested floodplains and in some drier upland areas, and seems to prefer sandy soils.

BACKGROUND: Lesser celandine was introduced to the United States as an ornamental plant. It is still available commercially in the U.S., along with many colorful varieties. All varieties of lesser celandine should be assumed to be invasive.

BIOLOGY & SPREAD: Lesser celandine is an exotic perennial plant and spring ephemeral that spends much of the year (summer through early winter) underground as thickened, fingerlike tubers or underground stems. During the winter, leaves begin to emerge and photosynthesize in preparation for flowering. Flowering usually occurs from late winter through mid-spring (March through May), depending on conditions. Afterwards, the above-ground portions die back. Lesser celandine spreads primarily by vegetative means through abundant tubers and bulblets, each of which is ready to become a new plant once separated from the parent plant.

The tubers of lesser celandine are prolific and may be unearthed and scattered by the digging activities of some animals, including well-meaning weed pullers, and transported during flood events.

CURRENT MANAGEMENT APPROACHES: Lesser celandine is very difficult to control but it can be managed with persistence over time using methods that are site appropriate. While manual methods are possible for some (small) infestations, the use of systemic herbicide kills the entire plant tip to root and minimizes soil disturbance.

Biological. No biological control agents are currently available for lesser celandine.

Chemical. The window of opportunity for controlling lesser celandine is very short, due to its life cycle. In order to have the greatest negative impact to celandine and the least impact to desirable native wildflower species, herbicide should be applied in late winter-early spring (March through May). Apply a 1.5% rate of a 39 to 41% glyphosate isopropylamine salt (e.g., Rodeo for wetland areas) mixed with water and a non-ionic surfactant to foliage, avoiding application to anything but the celandine. Glyphosate is systemic; that is, the active ingredient is absorbed by the plant and translocated to the roots, eventually killing the entire plant. The full effect on the plant may take 1-2 weeks. Applications can be made during the winter season as long as the temperature is above about 50°F, and no rain is anticipated within 12 hours. Because glyphosate is non-specific, spray should be controlled such that it touches only lesser celandine and does not drift onto desirable plants. To minimize impacts to sensitive-skinned frogs and salamanders, some experts recommend applying herbicide in March and then switching to manual methods.

Manual. For small infestations, lesser celandine may be pulled up by hand or dug up using a hand trowel or shovel. It is very important to remove all bulblets and tubers.

Mechanical. If mechanical removal is to continue after dieback of the plants, individual plants or clumps will need to be marked with some sort of stakes or flagging because it will be impossible to relocate the plants otherwise. When conducting mechanical removal, care should be taken to minimize soil disturbance as much as possible. For this reason, mechanical control may be inappropriate for large infestations in high quality natural areas.

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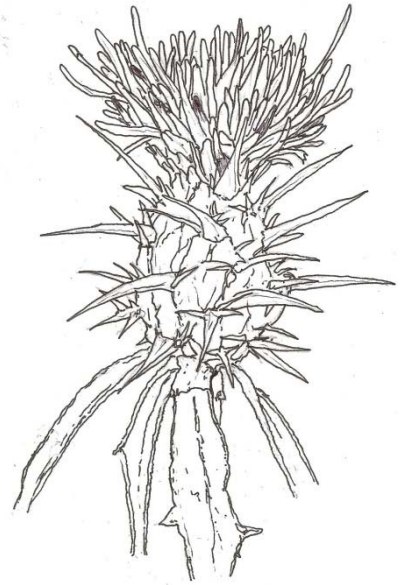
Malta Starthistle
Centaurea melitensis L.

Malta Starthistle
Malta starthistle was introduced to the southwestern U.S. from Europe as a seed contaminant. It is very similar to yellow starthistle in appearance, and is often mistaken for it. Like yellow starthistle, leaves extend down the stems, giving the stem a winged appearance. A major difference between the two star thistles is length of spines on the flower bracts: those of yellow starthistle are usually approximately an inch in length, while Malta starthistle spines are normally less than 1/2 inch long. Unlike yellow starthistle also, Malta starthistle seeds appear to have longer longevity in the soil: Malta starthistle seed lives for over 3 years in the soil, making it potentially more difficult to eradicate.

Horse Killer
Malta starthistle has been implicated in case reports of chewing disease of horses. Ingestion of significant quantities can cause “chewing disease” which is characterized by fatigue, lowered head, an uncontrolled rapid twitching of the lower lip, tongue-flicking, involuntary chewing movements, and an unnatural open position of the mouth.

Poisoning occurs after a horse has ingested 60 to 160% of its body weight over a two month period (Panter 1990, 1991). Toxicity effects are cumulative and irreversible. In most cases, poisoning occurs where horses had little or no other palatable feed available to them (Schalau 2005, UNCE undated).

Malta and Yellow Star Thistle, all thistles are bad news. These plants are as tough as nails. Communities across the southwest have set laws for controlling this pest. There are pest applicators that spread all day spraying and removing this plant. It is a nightmare, but a money maker for our industry.



PURPLE STAR THISTLE

RUSSIAN KNAPWEED

Musk Thistle

Seedlings normally emerge early in spring, develop into rosettes and spend the first season in this growth stage. Seedling emergence also can occur in fall. All seedlings grow into rosettes and overwinter in that stage. Rosettes are usually large and compact with a large, corky taproot that is hollow near the crown. Leaves have consistent shape, sometimes expressing a frosted appearance around the leaf margins, and often have a cream-colored midrib.

Early in spring of the second year, overwintered rosettes resume growth. Shoots begin to elongate in late March through May, depending on weather and elevation. Musk thistle flowers and starts to produce seed 45 to 55 days after it bolts. Musk thistle has very large bracts beneath flowers that are armed with sharp spines and shoots beneath flowers are almost devoid of leaves.

Musk thistle dies after it sets seed. It spends approximately 90 percent of its life cycle in a vegetative growth stage. Musk thistle's tolerance to most herbicides increases after it bolts.

Musk thistle is a prolific seed producer. One plant can set up to 20,000 seeds. However, only one-third of the seeds are viable. Musk thistle produces many heads. The terminal, or tallest, shoots flower first, then lateral shoots develop in leaf axils. A robust plant may produce 100 or more flowering heads.

Musk thistle flowers over a seven- to nine-week period. It begins to disseminate seed from a head about two weeks after it first blooms. It is common to observe musk thistle with heads in several stages of floral development and senescence. Thus, musk thistle sets seed over an extended time period.

Most seed is dispersed within the immediate vicinity of the parent plant. This leads to a clumped pattern of seedling development and results in intraspecific competition and mortality.

Wind and water are good dissemination methods and seeds are also spread by animals, farm machinery and other vehicles. Less than 5 percent of seed remains attached to the pappus when it breaks off the flowering head and floats away on wind currents.

Management

Cultural control. Maintaining pastures and rangeland in good condition is a primary factor for musk thistle management. To favor pasture and rangeland grass growth, do not overgraze. Fertilize only when necessary and according to soil testing recommendations. To successfully manage musk thistle, prevent seed formation.

Mechanical control. Musk thistle will not tolerate tillage and can be removed easily by severing its root below ground with a shovel or hoe. Mowing can effectively reduce seed output if plants are cut when the terminal head is in the late-flowering stage. Gather and burn mowed debris to destroy any seed that has developed.

Chemical control. Several herbicides are registered in pasture, rangeland and noncrop areas to control musk thistle. Tordon 22K (picloram), Milestone, Transline, Banvel/Vanquish/Clarity (dicamba), 2,4-D, or Banvel/Vanquish/Clarity plus 2,4-D are commonly used. Apply these herbicides in spring or fall to musk thistle rosettes. Applications during the reproductive growth stages with these herbicides (bud through flowering) will not eliminate viable seed development.

Escort (metsulfuron) or Cimarron Extra (chlorsulfuron) also can be used in pastures, rangeland, and non-crop areas. Research from Colorado State University and the University of Nebraska shows that chlorsulfuron or metsulfuron prevents or dramatically reduces viable seed formation when applied in spring, up to early flower growth stages.

The latest time to apply these herbicides is when developed terminal flowers have opened up to the size of a dime. Add a good agricultural surfactant at 0.25 percent v/v2 to Escort or Cimarron Extra treatments or control is inadequate (equivalent to 1 quart of surfactant per 100 gallons of spray solution).

Purple Loosestrife *Lythrum salicaria* L.

NATIVE RANGE: Eurasia; throughout Great Britain, and across central and southern Europe to central Russia, Japan, Manchuria China, southeast Asia and northern India

DESCRIPTION: Purple loosestrife is an erect perennial herb in the loosestrife family, with a square, woody stem and opposite or whorled leaves. Leaves are lance-shaped, stalkless, and heart-shaped or rounded at the base. Plants are usually covered by a downy pubescence. Loosestrife plants grow from four to ten feet high, depending upon conditions, and produce a showy display of magenta-colored flower spikes throughout much of the summer. Flowers have five to seven petals. Mature plants can have from 30 to 50 stems arising from a single rootstock.

ECOLOGICAL THREAT: Purple loosestrife adapts readily to natural and disturbed wetlands. As it establishes and expands, it outcompetes and replaces native grasses, sedges, and other flowering plants that provide a higher quality source of nutrition for wildlife. The highly invasive nature of purple loosestrife allows it to form dense, homogeneous stands that restrict native wetland plant species, including some federally endangered orchids, and reduce habitat for waterfowl.

DISTRIBUTION IN THE UNITED STATES: According to the U.S. Fish and Wildlife Service, purple loosestrife now occurs in every state except Florida.

HABITAT IN THE UNITED STATES: Purple loosestrife is capable of invading many wetland types, including freshwater wet meadows, tidal and non-tidal marshes, river and stream banks, pond edges, reservoirs, and ditches.

BACKGROUND: Purple loosestrife was introduced to the northeastern U.S. and Canada in the 1800s, for ornamental and medicinal uses. It is still widely sold as an ornamental, except in states such as Minnesota, Wisconsin, and Illinois where regulations now prohibit its sale, purchase and distribution.

BIOLOGY & SPREAD: Purple loosestrife enjoys an extended flowering season, generally from June to September, which allows it to produce vast quantities of seed. The flowers require pollination by insects, for which it supplies an abundant source of nectar. A mature plant may have as many as thirty flowering stems capable of producing an estimated two to three million minute seeds per year.

Purple loosestrife also readily reproduces vegetatively through underground stems at a rate of about one foot per year. Many new stems may emerge vegetatively from a single rootstock of the previous year. "Guaranteed sterile" cultivars of purple loosestrife are actually highly fertile and able to cross freely with purple loosestrife and with other native Lythrum species. Therefore, outside of its native range, purple loosestrife of any form should be avoided.

CURRENT MANAGEMENT APPROACHES: Small infestations of young purple loosestrife plants may be pulled by hand, preferably before seed set. For older plants, spot treating with a glyphosate type herbicide (e.g., Rodeo for wetlands, Roundup for uplands) is recommended. These herbicides may be most effective when applied late in the season when plant are preparing for dormancy. However, it may be best to do a mid-summer and a late season treatment, to reduce the amount of seed produced.

While herbicides and hand removal may be useful for controlling individual plants or small populations, biological control is seen as the most likely candidate for effective long term control of large infestations of purple loosestrife. As of 1997, three insect species from Europe have been approved by the U.S. Department of Agriculture for use as biological control agents.

These plant-eating insects include a root-mining weevil (*Hylobius transversovittatus*), and two leaf-feeding beetles (*Galerucella calmariensis* and *Galerucella pusilla*). Two flower-feeding beetles (*Nanophyes*) that feed on various parts of purple loosestrife plants are still under investigation. *Galerucella* and *Hylobius* have been released experimentally in natural areas in 16 northern states, from Oregon to New York. Although these beetles have been observed occasionally feeding on native plant species, their potential impact to non-target species is considered to be low.

USE PESTICIDES WISELY: ALWAYS READ THE ENTIRE PESTICIDE LABEL CAREFULLY, FOLLOW ALL MIXING AND APPLICATION INSTRUCTIONS AND WEAR ALL RECOMMENDED PERSONAL PROTECTIVE GEAR AND CLOTHING. CONTACT YOUR STATE DEPARTMENT OF AGRICULTURE FOR ANY ADDITIONAL PESTICIDE USE REQUIREMENTS, RESTRICTIONS OR RECOMMENDATIONS.

NOTICE: MENTION OF PESTICIDE PRODUCTS IN THIS COURSE DOES NOT CONSTITUTE ENDORSEMENT OF ANY MATERIAL.

Spotted Knapweed *Centaurea biebersteinii* DC.

SPOTTED KNAPWEED

NATIVE RANGE: Central Europe, east to central Russia, Caucasia, and western Siberia.
DESCRIPTION: Spotted knapweed is a biennial or short-lived perennial member of the Sunflower (Asteraceae) family. Its name is derived from the spots formed by black margins on the flower bract tips. Spotted knapweed typically forms a basal rosette of leaves in its first year and flowers in subsequent years. Rosette leaves are approximately 8 inches long by 2 inches wide, borne on short stalks, and deeply lobed once or twice on both sides of the center vein, with lobes oblong and wider toward the tip. The taproot is stout and deep. Flowering stems are erect, 8 to 50 inches tall, branched above the middle, and with sparse to dense hair. Stem leaves alternate along the stem, are unstalked, and may be slightly lobed, or linear and unlobed. Leaf size decreases towards the tip of the stem.

Flowers are purple to pink, rarely white, with 25 to 35 flowers per head. Plants bloom from June to October, and flower heads usually remain on the plant. Flower heads are oblong or oval shaped, ¼ inch wide and ½ inch across, and are single or borne in clusters of two or three at the branch ends. Leaf-like bracts surrounding the base of the flower head are oval and yellow green, becoming brown near the base. The margins of these bracts have a soft spine-like fringe, with the center spine being shorter than the lateral spines. The brown, oval seeds are 1/16 to 1/8 inch long, with pale longitudinal lines and a short fringe on one end.

ECOLOGICAL THREAT: Spotted knapweed infests a variety of natural and semi-natural habitats including barrens, fields, forests, prairies, meadows, pastures, and rangelands. It outcompetes native plant species, reduces native plant and animal biodiversity, and decreases forage production for livestock and wildlife. Spotted knapweed may degrade soil and water resources by increasing erosion, surface runoff, and stream sedimentation. It has increased at an estimated rate of 27% per year since 1920 and has the potential to invade about half of all the rangeland (35 million acres) in Montana alone.

DISTRIBUTION IN THE UNITED STATES: Spotted knapweed is a widely distributed species reported to occur throughout Canada and in every state in the U.S. except Alaska, Georgia, Mississippi, Oklahoma and Texas. It has been designated as a noxious weed in Arizona, California, Colorado, Idaho, Minnesota, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oregon, South Dakota, Utah, Washington, and Wyoming. It

has been identified as invasive in natural areas by eighteen organizations in twenty-six states (Arizona, California, Colorado, Connecticut, Delaware, Kentucky, Idaho, Illinois, Massachusetts, Maryland, Michigan, Minnesota, Montana, North Carolina, New Jersey, New York, Oregon, Pennsylvania, South Dakota, Tennessee, Utah, Virginia, Washington, Wisconsin, West Virginia, and Wyoming). Fifteen national parks also identify spotted knapweed as an invasive plant and a threat to natural habitats.

HABITAT IN THE UNITED STATES: Spotted knapweed is found at elevations up to and over 10,000 feet and in precipitation zones receiving 8 to 80 inches of rain annually. Spotted knapweed prefers well-drained, light-textured soils that receive summer rainfall, including open forests dominated by ponderosa pine and Douglas fir, and prairie habitats dominated by Idaho fescue, bluebunch wheatgrass, and needle-and-thread grass. Disturbance allows for rapid establishment and spread; however, spotted knapweed is capable of invading well managed rangelands. Spotted knapweed does not compete well with vigorously growing grass in moist areas. In seasonally dry areas, spotted knapweed's taproot allows it to access water from deep in the soil, beyond the reach of more shallowly rooted species.
BACKGROUND: Spotted knapweed was introduced to North America from Eurasia as a contaminant in alfalfa and possibly clover seed, and through discarded soil used as ship ballast. It was first recorded in Victoria, British Columbia in 1883 and spread further in domestic alfalfa seeds and hay before it was recognized as a serious problem.
BIOLOGY & SPREAD: Spotted knapweed plants in North America generally live 3 to 7 years but can live up to nine years or longer. Plants re-grow from buds on the root crown. Reproduction is by seed, and plants are capable of producing 500- 4,000 seeds per square foot per year. About 90% of the seeds are viable at the time of dispersal, and they can remain viable in the soil for 5-8 years. Most seeds are dispersed near the parent plant but can be transported by people, wildlife, livestock, vehicles, and in soil, crop seed, and contaminated hay. Gravel pits, soil stockpiles, powerlines, grain elevators, railroad and equipment yards are important seed distribution points.
CURRENT MANAGEMENT APPROACHES: The most cost effective management strategy for spotted knapweed is to prevent its spread to non-infested areas. Spread by seed can be minimized by avoiding travel through infested areas; by cleaning footwear, clothing, backpacks, and other items after hiking through infested areas; by not grazing livestock when ripe seeds are present in the flower heads; and by using weed-free hay.

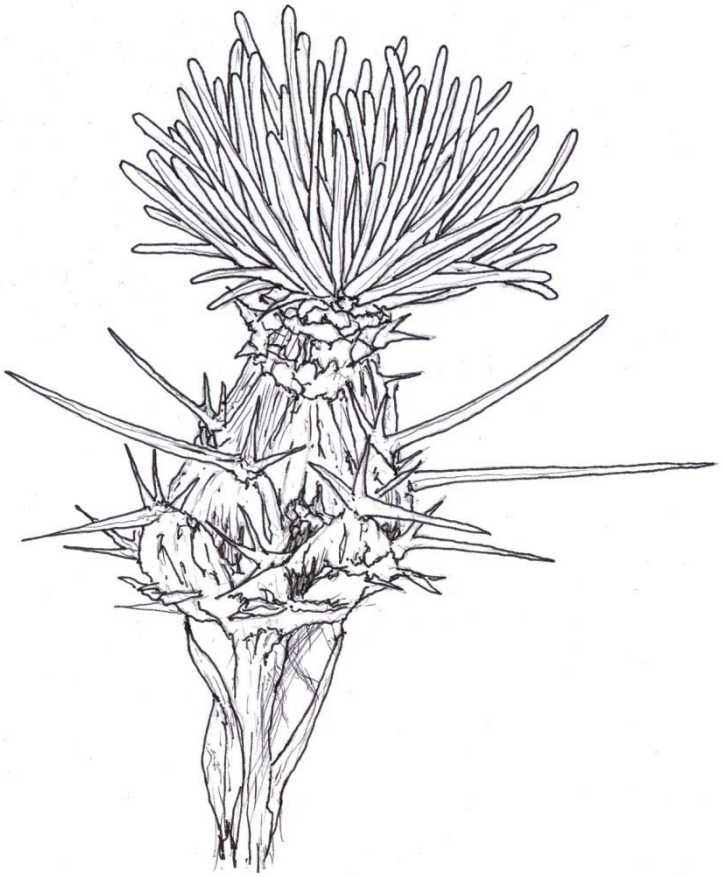
Manual and Mechanical. Small infestations of spotted knapweed can be controlled by persistent hand-pulling done prior to seed set. Gloves should be worn because of the possibility of skin irritation. Because spotted knapweed can re-grow from the base, care must be taken to remove the entire crown and taproot.

Biological control. A variety of natural enemies are used as biological control agents for large infestations of spotted knapweed. Most biocontrol techniques use insect larvae to damage the root, stem, leaf, or flower. Two species of seed head flies, *Urophora affinis* and *U. quadrifasciata*, are well-established on spotted knapweed. The larvae of these species reduce seed production by as much as 50% by feeding on spotted knapweed seed heads and causing the plant to form galls. Three moth species (*Agapeta zoegana*, *Pelochrista medullana*, and *Pterolonche inspersa*) and a weevil (*Cyphocleonus achates*) that feed on spotted knapweed roots have also been released.

The collective stress on the plant caused by these insects reduces seed production and may lead to reduced competitiveness. Biological control agents may be more effective when combined with other control methods such as herbicides, grazing, and revegetation with desirable, competitive plants.

Chemical. Control of spotted knapweed infestations using three chemical herbicides (2,4-D, clopyralid, and picloram) has been reported but is problematic. Existing plants can be killed with 2,4-D but it needs to be reapplied yearly to control new plants germinating from seed stored in the soil. Picloram is a more persistent herbicide and has controlled knapweed for three to five years when applied at 0.25 lb/acre at any stage of plant growth; or with clopyralid (0.24 lb/acre) or clopyralid (0.2 lb/acre) plus 2,4-D (1 lb./acre) applied during bolt or bud growth stage. In the absence of desirable native grasses, longevity of control may be increased by revegetating with competitive grasses and forbs. Picloram may pose a risk of groundwater contamination where soils are permeable, particularly where the water table is shallow.

Yellow Starthistle *Centaurea solstitialis L.*



YELLOW STAR THISTLE

Centaurea solstitialis is a grayish-green plant with multiple rigid stems that extend in all directions from the base, forming a bushy-looking cluster that can reach 2 meters (6.6 ft) in height and more than that in diameter. It produces bright yellow flowers ringed with long, sharp spines.

The plant grows quickly and is very competitive. It bears a taproot that can reach 1 meter (3.3 ft) deep into the soil, allowing it to thrive during dry, hot summers. It is versatile in its growth patterns, and can adapt to drought or low soil moisture content by producing smaller plants with fewer seeds during dry years.

Yellow star-thistle is a plant toxic to horses, causing chewing disease (Nigropallidal encephalomalacia).

Yellow starthistle originated from southern Europe, and first entered the United States shortly after the 1849 gold rush. It was imported as a contaminant in alfalfa hay. At that time, the only place California imported alfalfa from was Chile. It had been spread to Chile in the 1600's from Spain. By 1958, it infested over a million acres in California. Today, there are an estimated 16 million acres of yellow starthistle in California, and a couple of additional million acres in other western states. It has spread to 23 of the 48 contiguous states, as far east as New York.

Yellow starthistle is a winter annual that is a member of the knapweed complex in the sunflower family. It grows about 2-3 feet tall and has yellow flowers. Leaves extend down the edges of the stems, giving the stems a winged appearance.

Inflorescences have bracts with stiff, sharp spines that are about an inch long. A single starthistle plant has the potential to produce up to 150,000 seeds. Germination occurs either in the fall or spring; the young plant has a rosette growth form. As plants mature, a flower stalk elongates from the center of the rosette.

Although some studies show that some seeds can remain viable for up to 10 years (Callihan et al 1993), studies done in California under natural conditions demonstrated that 95% of the seeds had either germinated or were damaged after only 2-3 years in the soil (Joley et al 1992)

This plant has the ability to invade rangelands, pastures, croplands, and roadsides throughout the west, especially those with deep, loamy soils. The competitive success of yellow starthistle is directly related to its ability for rapid growth and capture of water, nutrients, light, and space. This species displaces native plant communities, reduces plant diversity, and accelerates soil erosion and surface runoff. It can form solid stands that drastically reduce forage production for livestock and wildlife. Its ability to deplete soil moisture has been compared to a loss of 15 to 25% of annual precipitation (Jetter et al. 2003).

Livestock can be injured eating even small amounts of yellow starthistle if forced to feed on the spiny portions of the plant. Animals and humans normally avoid heavily infested sites due to the spiny nature of the mature plants.

Human activities are the primary mechanisms for the long distance movement of yellow starthistle seed. Seed is transported in large amounts by road maintenance equipment and on the undercarriage of vehicles. The movement of contaminated hay and uncertified seed are also important long distance transportation mechanisms. Once at a new location, seed is transported in lesser amounts and over short to medium distances by animals and humans.

Grasses Section

Grasses are usually more difficult to identify than broadleaf weeds. It is especially useful to have a hand or pocket lens with 10x magnification power because grasses possess subtle characteristics that distinguish them from one another. Most of these identifying features are contained in the collar region. The collar region can be seen by carefully pulling the leaf blade back from the stem. When the blade is pulled back, look for the ligule. The ligule is a projection at the base of the leaf blade. If a ligule is present, it will appear as a ring of hair or it may be membranous (thin and almost transparent). It can be relatively large or small, and its tip can be jagged or smooth. Some grassy weeds will have auricles; these are small fingerlike structures that appear to clasp around the stem at the collar. Like broadleaf weeds, grasses may be hairy on either the top or bottom leaf surface, or both. Grass stems can be a key feature; most are rounded, while others are flattened. A few grassy weeds will also have hair on their stems.

Sedges can be relatively easy to distinguish from grasses and broadleaf weeds. From a distance, they appear grasslike; however, upon closer inspection, the stems are triangular in shape. The leaves on sedges usually appear very glossy or shiny in texture and the leaves are hairless and occur in sets of three.

Exotic Grass Control
Exotic grasses continue to spread and increasingly reside along highway right-of-ways and thus gain access to adjoining lands. Most exotic grasses are highly flammable, increasing fire intensities while promoting their spread after wildfire or prescribed burns, with wildland firefighters subjected to increased risks. Exotic grasses have become one of the most insidious problems in the field of wildlife management, because they can totally dominate pasture and prairie lands once established, having little wildlife value and leaving no room for native plants. Repeated applications of herbicides are required for control.

Cool Season Grasses

Kentucky Bluegrass (Poa pratensis)- This plant is readily identified by its boat-shaped leaf tip. This is the only cool season turfgrass with a boat-shaped tip. It spreads by rhizomes and tillers and forms a dense sod. New shoots (rhizomes and tillers) are produced primarily in the spring and late summer.

Creeping Bentgrass (Agrostis palustris)- This plant is a perennial cool season grass that forms a dense mat. The grass spreads by profuse creeping stolons and possesses rather vigorous, shallow roots. A defining characteristic of this plant is a long membranous ligule with auricles present.

Perennial Ryegrass (Lolium perenne)- This plant has a bunch-type growth habit with a folded vernation. There is a short membranous ligule present with short or absent auricles. One of the most recognizable characteristics of this plant is its shiny backside of the leaf blade.

Annual Ryegrass (Lolium multiflorum)- Annual ryegrass also has a bunch-type growth habit. However, this plant has a rolled vernation. The most notable characteristic of this plant is a claw-like auricle. The course leaf texture and prominent veination are also very notable characteristics.

Tall Fescue (Festuca arundinacea)- This plant has a bunch-type growth habit along with rolled vernation. The ligule is often short to long in length with short, blunt auricles. The leaf blade has a pointed tip with rough edges.

Warm Season Grasses

Buffalograss (Buchloe dactyloides)- This plant has a stoloniferous growth habit with a rolled vernation. There is a ligule present with a fringe of hairs but there are no auricles present. Most notable is pubescence on upper and lower surfaces.

Bermuda grass (Cynodon dactylon)- This plant can have rhizomes and/or stolons with a folded vernation. The ligule on this plant has a fringe of hairs as most other warm season grasses have. The best identifying characteristic of this plant is the uneven internodes on the stolons.

Zoysiagrass (Zoysia spp.)- This plant has a stonloniferous growth habit with a rolled vernation. The ligule has a fringe of hairs and there is no auricle. A helpful characteristic of this plant is the broad, continuous collar.

Bahia grass (Paspalum notatum)- The stolons on this plant are very thick along with a rolled or folded vernation. The ligule is membranous with a fringe of hairs.

Kikuyu grass (Pennisetum clandestinum) - Rhizomous and stoloniferous growth habit . This plant also has a folded vernation and a very smooth leaf blade.

St. Augustine grass (Stenotaphrum secundatum)- This plant also has a stoloniferous growth habit with a folded vernation. The ligule has a fringe of hairs and the leaf blade has a blunt tip. The ID characteristic of this plant is the 90 degree twist of the leaf blades.

Centipedegrass (Eremochloa ophiuroides)- This plant has the stoloniferous growth habit and the folded vernation. The ligule is membranous with a fringe of hairs. There is a very broad collar on this plant also.

More on Grasses and Reeds

Giant Reed *Arundo donax*

Nature: Large leafy reed to 20 ft. tall in clumps from dense branching rhizomes. Erect terminal flower stalks and seed heads appear in late summer, but no seed are produced. Spread is by rhizomes and movement of stem parts in soil or by road grading.
Origin: Native to western Asia, northern Africa, and southern Europe and introduced in the early 1800's.
Uses: Ornamental.
Herbicide Control: Apply a glyphosate herbicide as a 2% solution (8 ounces in a 3-gal. sprayer) or Arsenal AC as a 1% solution (4 ounces in a 3-gal. sprayer), or combination of the two herbicides in water with a surfactant to thoroughly wet all foliage in September or October with multiple applications to regrowth.

Tall Fescue *Lolium arundinaceum* and formerly Festuca arundinacea and F. elatior

Nature: Cool-season grass that is dark green year-round except in summer, with whitish-eared areas where blades connect to the stem and stems having swollen nodes. Certain varieties contain toxins poisonous to livestock and wildlife.
Origin: Introduced from the Europe, and now widely distributed most everywhere in the world.
Uses: Planted for improved pasture for livestock production, wildlife openings, and soil stabilization.
Herbicide Control: For non-crop lands, apply a mixture of Plateau at 10-12 dry ounces + a glyphosate herbicide at 1 qt. in 20 gal. water per acre in late summer or spring (consult the label for additives). For forestlands, substitute Arsenal AC at 24 ounces for Plateau. Other grass control herbicides that may be useful in pasture situations include Vantage, Poast, Assure, and Select, which are usually more costly than those discussed above. A non-herbicidal control method is repeated early spring burns that inhibits fescue and encourages native warm season grasses.

Cogon grass *Imperata cylindrica*

Nature: Dense, erect perennial grass with wide yellowish-green leaves having off-center midveins and finely saw-toothed margins. Spreads by wind-blown seeds in early summer and rhizome movement in fill-dirt along highways, yielding circular infestations. Highly flammable and a severe fire hazard.
Origin: Native to Southeast Asia and introduced into FL and lower LA, AL, and GA in the early 1900's.
Uses: Improved forage initially projected but without success, and initially for soil stabilization.
Herbicide Control: Apply a glyphosate herbicide as a 2% solution (8 ounces in a 3-gal. sprayer) or Arsenal AC as a 1% solution (4 ounces in a 3-gal. sprayer), or combination of the two herbicides in water with a surfactant to thoroughly wet all foliage in September or October with multiple applications to regrowth. Apply these herbicides in spring before flowering to suppress seed production to prevent spread. Multiple treatments in successive years will be required for eradication.

Nepalese Browntop *Microstegium vimineum*

Nature: Dense, mat-forming annual grass with stems growing to 1-3 ft. long, often laying over, having alternate, lanceolate leaves to 4 inches long. Shade tolerant and occupies various habitats including creek banks, floodplains, forest roadsides and trails, damp fields, and swamps. Consolidates occupation and spreads by prolific seed production in late summer.
Origin: Native to temperate and tropical Asia and introduced near Knoxville, TN around 1919.
Uses: Ground cover.
Herbicide Control: Apply a glyphosate herbicide as a 2% solution in water (8 ounces in a 3-gal. sprayer) with a surfactant in late summer. Vantage is a more selective grass control herbicide that can be used in specific locations (see label) that can be more effective and have less impact on associated plants than glyphosate herbicides. Repeat treatments for several years to control abundant germinating seeds. Mowing or pulling just prior to seed set in September will prevent seed buildup.

Chinese Silvergrass *Miscanthus sinensis*

Nature: Tall, densely tufted, perennial grass, upright to arching, 5-10 ft. tall, long-slender leaves with whitish upper midveins. Silvery to pinkish loose plumes appear in fall, with spotty seed viability. Highly flammable and a fire hazard.
Origin: Native to eastern Asia.
Uses: Still widely sold and planted as an ornamental.
Herbicide Control: Apply Arsenal AC as a 1% solution (4 ounces in a 3-gal. sprayer) or a glyphosate herbicide as a 2% solution (8 ounces in a 3-gal. sprayer), or a combination of the two herbicides in water with a surfactant to thoroughly wet all foliage in September to October, with multiple applications to regrowth.

Mechanical Weed Control: Mechanical weed control involves the physical destruction of a weed. Techniques involve hand pulling and hand hoeing which are practical for small infestations. Mowing is often used; but by far, the most common practice of mechanical control includes tillage. Advantages of tillage include:
• Elimination of weed debris
• Control of annual weeds
• Suppression of perennial weeds
• Tillage methods include plowing, rototilling, disking, and harrowing. Weed control implements include sweeps, rolling cultivators, finger weeders, push hoes, rotary hoes, etc.

Downy Brome or Cheatgrass *Bromus tectorum* L.

DOWNY BROME

Common Names: cheatgrass, brome, downy brome, drooping brome,thatch bromegrass, broncograss, military grass, downy chess, early chess, soft chess, wild oats

Native Range: Europe, the northern rim of Africa, and southwestern Asia.

Description: A winter annual in the grass family (Poaceae), bearing many finely hairy, drooping, yellowishgreen, bristly spikelets in a loose, much-branched, terminal cluster. It forms small tufts 8-24 inches tall, from a fine fibrous root system. Stems are erect and slender. Leaf blades are flat and pubescent. The inflorescence is a dense, drooping panicle 1 ½ to 8 inches long and is pale green to purplish in color. Branches are thin, flexuous, and pubescent. Spikelets are four to seven-flowered and pubescent or villous. Cheatgrass reproduces by seed that germinates in the fall, over winters as a seedling, then flowers in the spring. Seeds have the potential to remain viable in the seed bank for 2 to 5 years.

Habitat: It grows on rangelands, pastures, prairies, fields, waste areas, eroded sites, and roadsides. It exists in many climatic areas but primarily in the 6-27 inches precipitation zone. It will grow in almost any type of soil, however, is most commonly found on coarse textured soils on B and C horizons of eroded areas and areas low in nitrogen with soil temperatures between 2.0-3.5°C and 15°C. Litter promotes germination and establishment of seedlings.

Distribution: This species is reported from states shaded on Plants Database map. It is reported invasive in AZ, CA, CO, CT, HI, ID, NE, NJ, NV, OR, PA, SD, TN, UT, WA, WV, and WY.
Ecological Impacts: Many of the ecosystems that cheatgrass has invaded are seriously altered, and no longer support the vegetation of the potential natural community. Cheatgrass can maintain dominance for many years on sites where native vegetation has been eliminated or severely reduced by grazing, cultivation,or fire. At maturity the spikelets break apart; the sharp-pointed, bristly sections can injure grazing animals by working into the nose, ears, mouth, or eyes. Spikelets can also cling to hikers' clothing. It tends to be most invasive in areas receiving 12 to 22 inches of annual precipitation.

Control and Management:

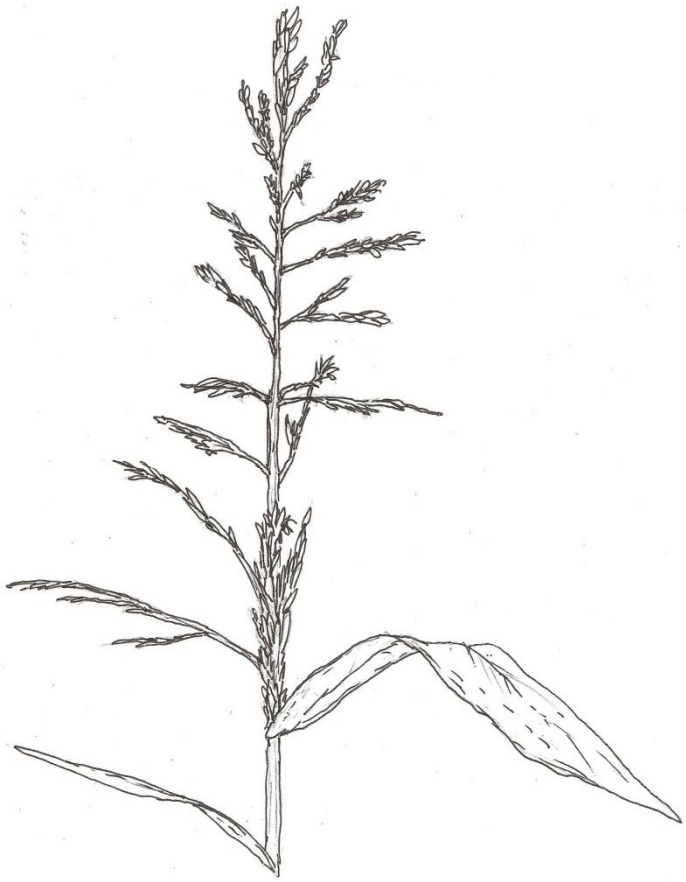
• **Manual**- Fire, mowing, grazing, tillage, and inter-seeding of competitive native plants have all been shown to reduce populations.

• **Chemical**- It can be effectively controlled using any of several readily available general use herbicides such as glyphosate Follow label and state requirements.

• **Biological control** is limited. Rabbits and mice will feed extensively on this species as do migratory grasshoppers (*Melanoplus sanquinipes*). It is often infected with a head smut (*Ustilago bulleta* Berk.) that, when severe, may reduce seed yield. Some research has been conducted on pink snow mold (*Fusarium nivale*) as a biological control agent, but information has yet to be released.

QUACKGRASS

Johnson Grass *Sorghum halepense* (L.) Pers.



JOHNSON GRASS

Johnson grass is a tall, coarse, perennial grass with stout (up to 3/4 inch in diameter) rhizomes. It grows in dense clumps or nearly solid stands and can reach 8 feet (2.4 meters) in height. Leaves are smooth, 6 to 20 inches (15.2 to 50.8 cm) long, and have a white or light green midvein. Stems are pink to rusty red near the base. Panicles are large, loosely branched, purplish, and hairy. Spikelets occur in pairs or threes and each has a conspicuous awn. Seeds are reddish-brown and nearly 1/8 inch (0.3 cm) long. Johnson grass should be accurately identified before attempting any control measures. If identification of the species is in doubt, the plant's identity should be confirmed by a knowledgeable individual and by consulting appropriate books.

Similar Species

Sorghum halepense with its white leaf vein, wide leaves, and reddish seed head is distinguished from (1) eastern gama grass *(Tripsacum dactyloides*), which has flowers in a spike rather than a loose panicle; (2) switch grass (*Panicum virgatum*), which has no white vein and a greenish-yellow seed head; (3) big bluestem (*Andropogon gerardii*) and Indian grass (*Sorghastrum nutans*) which both have narrower leaves and usually lack a prominent vein. Johnson grass can be distinguished from Sudan grass (*Sorgham bicolor ssp. drummondii*) by the fact that Sudan grass is an annual and therefore has no rhizomes.

Distribution

Originally native to the Mediterranean, this grass now occurs in all warm-temperate regions of the world. It is widely distributed in tropical America, and is common in the southern U.S. Heavy infestations are found in all the major river bottoms.

Habitat
This species occurs in crop fields, pastures, abandoned fields, rights-of-way and forest edges, and along stream banks. It thrives in open, disturbed, rich, bottom ground, particularly in cultivated fields. Heavy river-bottom infestations can reduce corn or soybean yields in Missouri to a few bushels per acre.

Life History
Johnson grass is a very aggressive, perennial grass. It occurs in dense clumps that spread by seed and rhizomes to form nearly pure stands. The thick rhizomes live over winter and in the spring send out new, white, spur-like shoots. In clay soils 80 percent of the rhizomes are in the top four inches of soil. In sandy loam soil, 80 percent occur in the top 6 inches. However, rhizomes may grow downward through cracks to a depth of 10 to 20 inches. The grass leaves emerge late in spring and the plant forms seed by July 1. A single plant may produce more than 80,000 seeds per year. Stems and leaves die back after the first frost, but the dead litter often covers the ground all winter. Rhizome cuttings commonly form new plants, making it very difficult to eradicate. It spreads rapidly and is not affected by many of the agricultural herbicides.

Effects Upon Natural Areas
Johnson grass invades riverbank communities and disturbed sites, particularly fallow fields and forest edges, where it crowds out native species and slows succession. It quickly dominates the herbaceous flora, reduces plant diversity, and is unsightly to observers. This grass is a serious potential threat in many old fields where succession to forest communities is desired.

Control Recommendations
Control Practices
To eradicate Johnsongrass, control measures must be thorough. Various cultural practices and chemical herbicides will effectively control germinating seed, seedlings, and established plants. Objectives of a Good

Control Program:
1. Prevent production and spread of seed
2. Destroy seedlings before rhizomes are formed
3. Weaken and kill existing rhizomes
4. Control new infestations as they appear

Recommended practices in natural communities of high quality
Initial effort in areas of heavy infestation
Johnson grass does not infest areas of high natural quality heavily except for the naturally disturbed environment such as along river banks where it is difficult to control selectively. Seed panicles should be cut and removed from the area where practical. Dense patches can be controlled by spraying the foliage with 2 percent Roundup (a formulation of glyphosate). Best results are obtained when glyphosate is applied to plants that are 18 inches tall to early flowering stage.

During this period the herbicide will be most effectively translocated to the roots and rhizomes. Care should be taken to avoid contacting non-target plants, since Roundup is a nonselective herbicide. Do not spray so heavily that herbicide drips off the target species. The herbicide should be applied while backing away from the area to avoid walking through wet herbicide. By law, herbicides may only be applied as per label instructions.

Effort in areas of light infestation
Clumps and individual plants may be hand pulled during June, just after a rain when the ground is soft. All plant parts should be removed from the area. Broken stems and roots left in the ground should be dug up if only a small area is involved. It is more effective to spot-treat the individual plants with herbicide than to pull them, and large clumps can be sprayed with 2 percent Roundup using a hand sprayer or backpack sprayer. Herbicide treatment may need to be repeated for several years to ensure good control.

Maintenance control
Preferred treatment is hand pulling of individual plants immediately upon discovery. All plant parts, including rhizomes, must be removed. It may be necessary to hand pull a population several times to obtain control. Surrounding seed sources should be eliminated where possible to prevent continual re-invasion.

Recommended practices on lands other than high-quality natural areas
Initial effort in areas of heavy infestation
Repeated and close mowing kills Johnson grass seedlings, prevents seed production, and reduces rhizome growth and regrowth of shoots. Sites may be tilled where it is practical (e.g. abandoned cropland) and the exposed roots left to winter kill. Repeated tillage (e.g. six times at two-week intervals during the growing season) prevents rhizome development and reduces Johnson grass populations. Limited early season tillage, however, encourages rhizome growth by spreading pieces of the rhizomes. In a monoculture, livestock may be used to eliminate the Johnson grass by grazing. Spraying 2 percent Roundup on foliage using a tractor and power sprayer provides effective control.

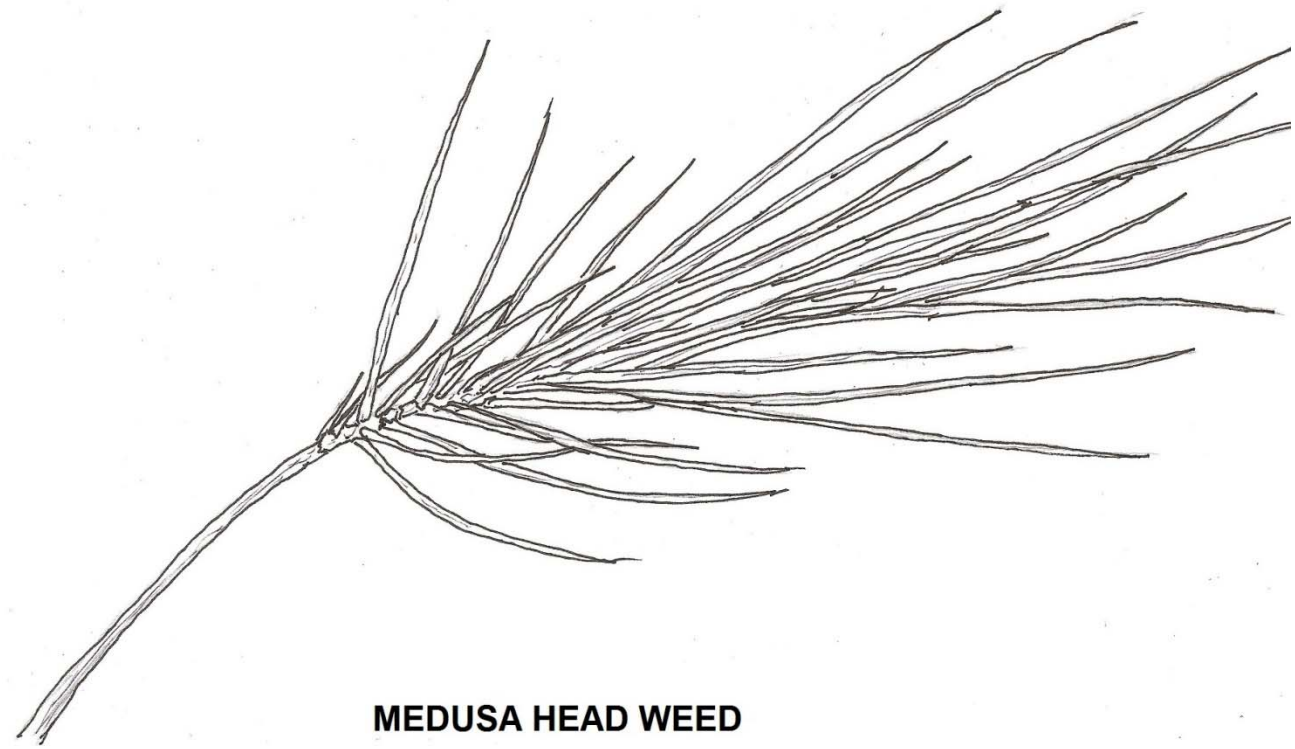
Effort in areas of light infestation
Cutting and removal of seed heads during early July and then spot application of 2 percent Roundup to the foliage usually will be effective if continued for three to four years.

Maintenance control
Preferred treatment is the same as given above for high-quality areas. Another treatment is spot application of 2 percent Roundup to eliminate invading individuals the first year and to eliminate all surrounding seed sources.

Failed or Ineffective Practices
The following practices should be avoided:

- Hand control: too slow and not practical in large areas where infestations are heavy. Rhizomes break easily and are often left in the ground. Large mature plants are almost impossible to pull by hand.
- Mowing: usually does not kill or eliminate established plants.
- Fire: more research needed. Spring burns may encourage regrowth.
- Herbicides: single applications seldom eliminate the species from an area.
- Tillage: not practical in many places because of terrain and erosion hazard. It seldom is effective by itself and allows other weedy species to invade. It may also destroy native species present.
- Grazing: Grazing increases the potential for introducing other exotic plants. Livestock trample the soil and damage other species.
- Manipulation of water levels: Johnson grass does not typically occur in areas where water level manipulation is practical.
- Biological controls: livestock grazing may reduce plant vigor, but has negative impacts (e.g., excessive trampling, damage to other species, soil compaction) associated with it. No other biological controls are known that are feasible in natural areas.

Medusahead *Taeniatherum caputmedusae*



Medusahead is an annual grass native to Eurasia. A low-value forage species for livestock and wildlife, it has been estimated that the carrying capacity of rangeland for domestic livestock has been reduced by 75% after medusahead invasion.

Distribution
Medusahead has spread throughout the annual dominated ranges of northern and central California.

Imposters
Sometimes confused with foxtail barley or squirreltail. Medusahead can be singled out by its spike, and seed head that does not break apart as seeds mature. Individual awnedflorets fall away, leaving twisted awns that will hold all winter.

Medusahead Squirreltail
Twisted awns or beards has open spikes and are good characteristics long, minutely of medusahead. Produces pale green, bushy, open spikes.

What does Medusahead look like and where does it grow?
Habitat: Medusahead inhabits disturbed sites, grassland, openings in chaparral, oak woodlands, and rangelands. It tends to grow best on clay soils where deep soil moisture is available late in the growing season. However meduahead can also be a problem on sandy soil in many areas of California.

Growth: Medusahead is a winter annual.Medusahead matures 2-4 weeks later then downy brome and other winter annual grasses. The yellowish-green sheen of dense stands is highly visible after other annual grasses turn brown. The stemsare wiry and slender and contain a few short narrow leaves. Medusahead tissues have a high silica content and low palatability except during the early growth stages. The high silica content also makes the Medusahead litter of dead stems slow to decompose.

Roots: Medusahead quickly develops a fibrous root system allowing it to extract available soil moisture deep in the soil profile.

Seeds: Reproduces by seed. Seeds disperse locally with wind, water, and by clinging to the feet and fur of animals. Germination is typically rapid and occurs under a broad temperature range. Most seeds germinate in fall after the first rain, but some seeds remain dormant or germinate in winter or spring.

Management & Control Methods
Mechanical- Tillage will control existing medusahead plants and can be used to break up deep thatch layers. But, it can increase potential for soil erosion and loss of soil moisture. Mowing is not an effective control strategy for medusahead.

Biological- Biological control of Medusahead does not appear to be a potential management option in the near future.

Chemical- Herbicides are a good tool for managing Medusahead populations and often improve the success of other control methods such as tillage, burning, or re-vegetation. Check with your Agriculture Department or Cooperative Extension office to determine the Herbicides that work best for your situation.

Grazing-Cattle and sheep will graze medusahead early in the season before seeds set, however medusahead's low palatability prevents grazing from being an effective control option.

Fire- Burning can help remove medusahead's dense thatch layer. When medusahead seeds are in the soft dough stage, a slow, hot fire can reduce medusahead plant density up to 90% the following year.

Re-vegetation- Establishing a healthy, desirable plant community must follow Medusahead control to prevent re-invasion. Seeding in late fall or early spring with a rangeland drill provides the best chance of re-vegetation success in arid, dry land situations. Consult your Cooperative Extension or NRCS office, to obtain more information on plant species that grow well in your area.

What can you do?

- Recognize medusahead. Understand the lifecycle so you can manage accordingly. Effective tools applied at the wrong time can aggravate the situation.
- Prescribed burning, specialized cultivation, and plant competition are effective non-chemical tools for managing medusahead.
- If you choose to use chemical control, work with the Agriculture Department to apply the right chemical at the correct rate, time and stage of growth and satisfy legal requirements.
- Drive on established roads and trails so as not to transport weed seed from infested areas.
- Remove weed seeds from vehicle and bicycle tires as well as shoes, clothing & animals.
- If you see a few plants, pull them. Pulled plants should be burned or tightly bagged prior to disposal. Do not put them in your compost.
- Maintain good vegetative cover of land to minimize infestation of noxious weeds.
- Feed weed-free forages to livestock to avoid unintentionally contaminating an area.
- If a weed-infested area is found, inform the landowner or manager so they can take steps to control the weeds (or notify the Agriculture Department).
- If you would like help in designing your personal weed strategy, please contact the Agriculture Department or Cooperative Extension.
- As with most things, diligent persistence and hard work reaps the greatest rewards.

Exotic Bamboo Section

Bamboos are divided into clumpers or runners, which can have a major impact on how well behaved they will be in your garden.

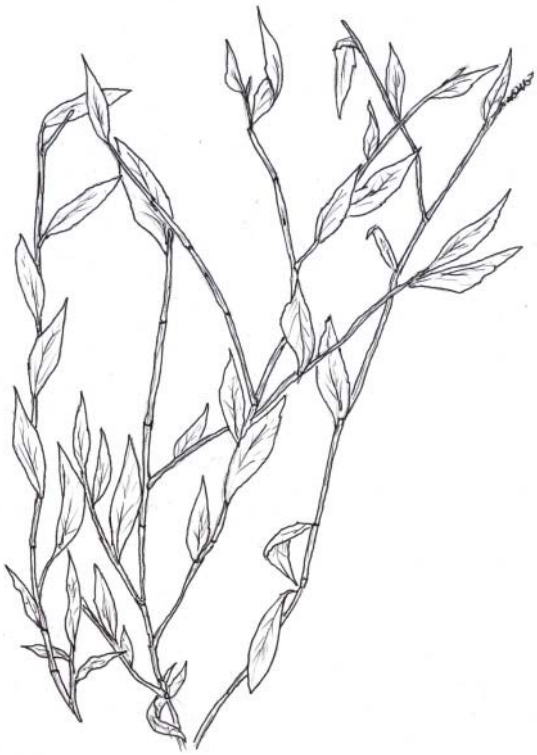
Clumping bamboos
Clumping types have a very short rhizomatous root structure and are incapable of expanding more than a few inches a year and will generally form discrete clumps. The clumps slowly enlarge as new culms emerge every year, and may require anywhere from 2-10 feet or more of space in order to reach their mature height, depending on species. Except for species of the genus *Fargesia*, the clumpers tend to be less cold-hardy than runners.

Clumping bamboos generally do not require control. They may be shaped by removing new shoots at soil level when they begin to encroach more closely on nearby structures.

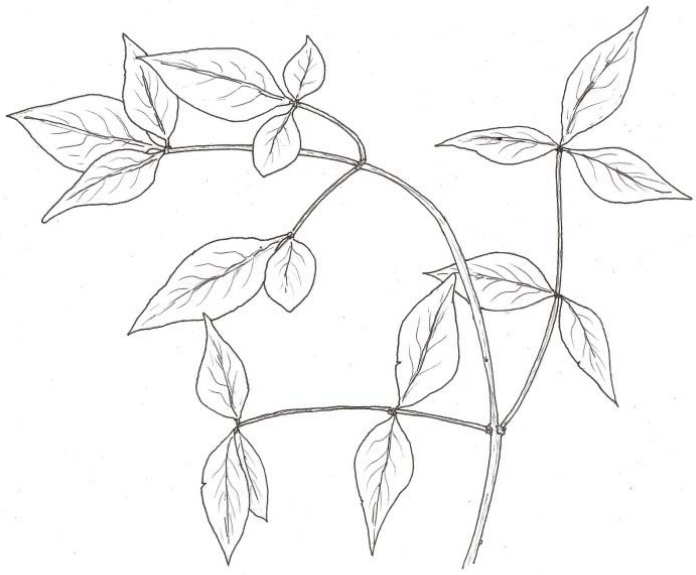
Running bamboos
Running types spread by sending out underground runners, or rhizomes, which sometimes emerge far from the parent plant. Runners fill in the spaces between plantings faster, making them ideal for screens, hedges, and the popular open grove look. Runners may be contained, as described below, since the rhizomes grow sideways at a depth of about 2-18 inches. Many are cold-hardy. Following are some strategies you can try for containing and eradicating running bamboos.

Integrated Pest Management Strategies
1. **Contain the running bamboo with a physical barrier.** The safest containment methods for running bamboo are 1) Planting in containers, or 2) Installing a vertical 30-40 mil thick plastic rhizome barrier 22-30 inches deep around the perimeter of the area in which the bamboo is to be contained. The advantage of this material is that even large plantings of bamboo can be surrounded with a single length of plastic, requiring only one seam. It is preferable to cement (which often develops cracks), or metal (which rusts and requires many seams), is less expensive, and lasts 20-30 years if installed properly. Please refer to The American Bamboo Society for detailed installation instructions.
2. **Cut off unwanted shoots.** The active growth period usually lasts for only about 2 weeks every spring, then little or no additional new growth will occur until the following spring. Therefore, cut off any shoots you don't want but remember all of the culms (stalks) of bamboo in a clump or grove are interconnected underground by rhizomes (underground stems). New shoots will grow again next year. If the bamboo in your yard comes from another's yard, separate your grove from his by cutting the connecting rhizomes, which are usually quite shallow. If this isn't done, and his part is healthy and vigorous, the rhizomes in your part will still be supported by the photosynthesis in the leaves of his part, and your efforts will be in vain. Cutting rhizomes with a spade or a saw will do the trick if it is done every year. If the growth is old, you may need to use a mattock or a digging bar the first time. Digging a ditch and putting in a barrier is a more permanent solution.
3. **Mow unwanted shoots in lawn areas.** If the bamboo is surrounded by lawn, then just mow frequently over the area where the bamboo is coming up during the spring shooting season.
4. **Many years of effort may be needed to eradicate running bamboo.** Begin by either digging as much of the root system out as possible – no easy job – or cutting the bamboo to the ground and then continue by following up with regular removal. New shoots will come up from the rhizomes. Break them off or cut them off with pruning shears. Keep doing this until no more shoots come up. This will exhaust the energy stored in the rhizomes underground. Without green leaves to photosynthesize and produce new energy, they will no longer be able to send up new shoots. The rhizomes will be left behind, but will rot away. This is a slow, labor intensive process.
5. **Using chemical weed killers may be helpful.** Be warned bamboo doesn't respond well to any herbicide currently on the market. If glyphosate (Round Up) is used, remember it is taken in through the leaves only, and it must be applied in an undiluted form. Often the plants will still re-shoot. Some have used a "cut and paste method" with some success. Each culm is cut to within 6" of the ground and immediately (within 15 seconds) painted with concentrated glyphosate.
It has been noted that imazapyr (Arsenal) is more effective on bamboo than glyphosate. However, imazapyr has a great deal of foliar and soil activity and can be very harmful to nearby hardwood trees, shrubs, and all

grasses if their roots extend into the vicinity of the application. Therefore, if the bamboo is growing near any desirable plant species, imazapyr should not be used. Glyphosate does not have soil activity and will only kill plants that are contacted with the spray solution. This makes glyphosate a more useful herbicide option for most areas where bamboo grows. It is important to note that one application of glyphosate will not eradicate bamboo. It will most likely be necessary to mow and spray as many as 4 times for complete bamboo control to be achieved. Persistence is key when targeting running bamboo.



JAPANESE STILTGRASS



SACRED BAMBOO

Golden Bamboo

Bambusa vulgaris, also known as **Golden Bamboo**, or **Buddha's Belly Bamboo**, is an open-clump type bamboo species. It is native to Indochina and to the Province of Yunnan in southern China, but it has been widely cultivated in many other places and has become naturalized in several. Among bamboo species, it is one of the largest and most easily recognized.

Description

Bambusa vulgaris forms moderately loose clumps and has no thorns. It has lemon-yellow culms (stems) with green stripes and dark green leaves. Stems are not straight, not easy to split, inflexible, thick-walled, and initially strong. The densely tufted culms grow 10–20 meters (30–70 ft) high and 4–10 centimeters (2–4 in) thick. Culms are basally straight or flexuose (bent alternately in different directions), drooping at the tips. Culm walls are slightly thick. Nodes are slightly inflated. Internodes are 20–45 centimeters (7.9–17.7 in). Several branches develop from mid-culm nodes and above. Culm leaves are deciduous with dense pubescence. Leaf blades are narrowly lanceolate.

Flowering is not common, and there are no seeds. Fruits are rare due to low pollen viability caused by irregular meiosis. At the interval of several decades the whole population of an area bloom at once, and individual stems bear a large number of flowers. Vegetation propagates through clump division, by rhizome, stem and branch cutting, layering and marcotting. The easiest and most practiced cultivation method is culm or branch cutting. In the Philippines, the best results were obtained from one-node cuttings from the lower parts of six-month-old culms. When a stem dies, the clump usually survives. A clump can grow out of stem used for poles, fences, props, stakes or posts. Its rhizomes extend up to 80 cm before turning upward to create open fast-spreading clumps. The easy propagation of *B. vulgaris* explains its seemingly wild occurrence.

The average chemical composition is cellulose 41–44%, pentosans 21–23%, lignin 26–28%, ash 1.7–1.9%, and silica 0.6–0.7%.

Taxonomy

The bambusoid taxa have long been considered the most "primitive" grasses, mostly because of the presence of bracteate, indeterminate inflorescences, pseudospikelets (units of the inflorescence in woody bamboos, consisting of one to many flowers and associated glumes, that rebranch to produce successive orders of spikelets), and flowers with three lodicules (minute scales of the florets of grasses, found between the lemma and the sexual organs of the flower), six stamens, and three stigmas. Bamboos are some of the fastest growing plants in the world.

Bambusa vulgaris is a species of the large genus *Bambusa* of the clumping bamboo tribe Bambuseae, which are found largely in tropical and subtropical areas of Asia, especially in the wet Tropics. The pachymorph (sympodial or superposed in such a way as to imitate a simple axis) rhizome system of clumping bamboos expands horizontally by only a short distance each year. The shoots emerge in a tight or open habit (group), depending on the species; common bamboo has open groups. Regardless of the degree of openness of each species' clumping habit, none of the clumpers are considered invasive. New culms can only form at the very tip of the rhizome. The Bambuseae are a group of perennial evergreens in subfamily Bambusoideae, characterized by having three stigmas and tree-like behavior, that are in turn of the true grass family Poaceae.

Cultivars

At least three groupings of *B. vulgaris* cultivars can be distinguished:

- Plants with green stems
- Golden bamboo (plants with yellow stems): Plants always with yellow stems and often with green stripes of different intensity. Usually the stems have thicker walls than those of the green stem group. This group is often distinguished as *Bambusa vulgaris var. Striata*.
- Buddha's belly bamboo: Plants with stems up to about 3 meters (9.8 ft) tall, 1–3 centimetres (0.4–1 in) in diameter, green, with 4–10 centimeters (2–4 in) long inflated internodes in the lower part. This group is often distinguished as *Bambusa vulgaris var. Wamin*.

The more common cultivars are described below:

- **Aureovariegata** (*Bambusa vulgaris var. aureovariegata* Beadle): With rich golden yellow culms striped in green, sometimes in very thin lines, it is the most common variety of *B. vulgaris*.
- **Striata** (*Bambusa vulgaris var. striata* (Lodd. ex Lindl.) Gamble): A common variety, smaller in size than other varieties, with bright yellow internodes and random markings with longitudinal stripes in light and deep green.
- **Wamin** (*Bambusa vulgaris f. waminii* T.H.Wen): It is smaller in size than other varieties with short and flattened internodes. Likely to have originated in South China, Wamin Bamboo is spread throughout East Asia, South East Asia, and South Asia Basally inflated internodes give it a unique appearance.
- **Vittata** (*Bambusa vulgaris f. vittata* (Rivière & C.Rivière) McClure): A common variety that grows up to 12 meters (39 ft) tall, it has barcode-like striping in green.
- **Kimmei**: Culms yellow, striped with green.
- **Maculata**: Green culms mottled with black, turning mostly black with aging.
- **Wamin Striata**: Grows up to 5 meters (16 ft) tall. Light green striped in dark green, with swollen lower internodes.

Distribution and habitat

Popular as a hothouse plant by the 1700s, it was one of the earliest bamboo species introduced into Europe. It is believed to have been introduced to Hawaii in the time of Captain James Cook (the late 18th century), and is the most popular ornamental plant there. *B. vulgaris* is widely cultivated in the USA and Puerto Rico, apparently since introduction by Spaniards in 1840. It may have been the first foreign species introduced into the United States by Europeans.

Ecology

B. vulgaris grows mostly on river banks, road sides, wastelands, and open ground, generally in the low altitudes. It is a preferred species for erosion control. It grows best under humid conditions, but can tolerate unfavorable conditions like low temperatures and drought. Though adoptable to a wide range of soils, the common bamboo grows more vigorously on moist soils. It can tolerate frost up to −3 °C (27 °F), and can grow on ground up to 1,500 meters (4,900 ft), though in higher altitudes stems grow shorter and thinner. In extreme droughts it may defoliate completely.

Golden Bamboo *Phyllostachys aurea*

Other Exotic Invasive Bamboos (Phyllostachys spp. and Bambusa spp.)
Nature: All bamboos that form extensive infestations besides the native switchcane (Arundinaria gigantea). All have jointed cane stems with bushy tops of long-pointed grass-like leaves on branching stems.
Origin: All native to Asia.
Uses: Ornamentals and fishing poles.
Herbicide Control: Apply a glyphosate herbicide as a 4% solution (1 pint in a 3-gal. sprayer) or Arsenal AC (or Chopper) as a 3% solution (12 ounces in a 3-gal. sprayer), or combination of the two herbicides in water with a surfactant to thoroughly wet all foliage in September or October, with multiple applications to regrowth. Apply these same herbicides or mixture at twice strength immediately to stems cut just above ground level.

YELLOW BAMBOO

Phyllostachys aureosulcata **-** Yellow groove bamboo is a giant temperate timber bamboo from Chekiang Province, China. The bamboo was introduced for trial as a stake and forage bamboo, and a farm usage crop. This is the most aggressive cold hardy running bamboo with maximum height of 45 feet / cold hardy to -15 F.

The invasion and damages are continual each year. From July to September rhizomes deeply invade underground, undetected in a 360 pattern around each cane. The bamboo then goes dormant until late April. From late April through June the invasion appears as spikes which shoot off the previous year's rhizomes. The culms can grow two feet per day. The bamboo is highly destructive and destroys everything in its path. Each successive invasion is more destructive than the previous year's. The spread is rapid in all directions.

Fountain Grass *Pennisetum setaceum* (Forsk.) Chiov

NATIVE RANGE: Northern Africa

DESCRIPTION: Fountain grass is an attractive perennial grass with a densely clumped growth form and erect stems that grow 2 to 3 feet high. The small flowers of fountain grass are grouped in pink or purple, bristly, upright inflorescences 6-15 inches long. Fruits are small, dry achenes adorned with long showy bristles.

ECOLOGICAL THREATS POSED BY PLANT: Fountain grass is a highly aggressive, fire-adapted colonizer that readily outcompetes native plants and rapidly reestablishes after burning. In Hawaii, where it alters the natural fire regime, fountain grass is a major threat to some critically imperiled plant species and natural communities. Fountain grass raises fuel loads, which increases the intensity and spread of a fire, and results in severe damage to native, dry forest species adapted to less extreme fire regimes.

DISTRIBUTION IN THE UNITED STATES: Fountain grass is found in Arizona, California, Colorado, Hawaii, Florida, Louisiana, and Tennessee. In the Hawaiian islands, it is found on the islands of Kauai, Oahu, Lanai, and Hawaii.

HABITAT IN THE UNITED STATES: In Hawaii, fountain grass invades many types of natural areas, from bare lava flows to rangelands. It has a wide elevation range but is limited to areas with a median annual rainfall of less than 50 inches. In southern California, fountain grass invades grasslands, deserts, canyons and roadsides.

BACKGROUND: First collected in Hawaii in 1914, fountain grass has been introduced to many parts of the world as an ornamental grass. It is a poor pasture grass and a serious weed in many dry habitats.

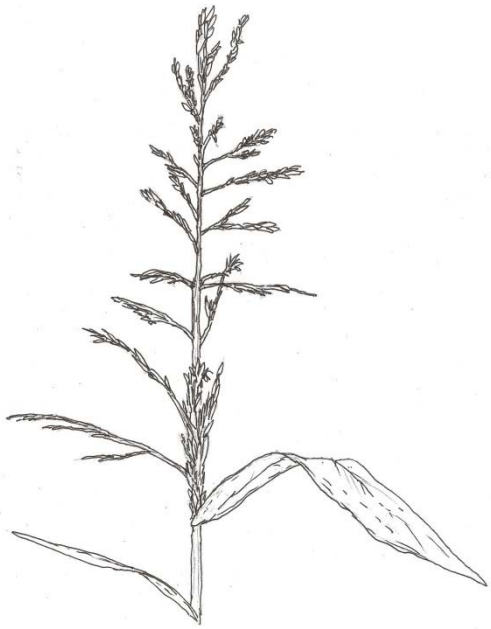
BIOLOGY & SPREAD: Fountain grass is a perennial plant with primarily wind-dispersed seeds that may remain viable in the soil for six years or longer. Its seeds may be dispersed greater distances by water, vehicles, livestock and humans.

CURRENT MANAGEMENT APPROACHES: The long-lived seeds of fountain grass make its control extremely difficult. Small infestations may be managed by uprooting plants by hand and destroying the inflorescences in order to prevent seed dispersal. Removal by hand may need to be repeated several times per year. Extensive infestations of fountain grass are probably best controlled with the help of herbicides, especially those with some systemic activity.

USE PESTICIDES WISELY: ALWAYS READ THE ENTIRE PESTICIDE LABEL CAREFULLY, FOLLOW ALL MIXING AND APPLICATION INSTRUCTIONS AND WEAR ALL RECOMMENDED PERSONAL PROTECTIVE GEAR AND CLOTHING. CONTACT YOUR STATE DEPARTMENT OF AGRICULTURE FOR ANY ADDITIONAL PESTICIDE USE REQUIREMENTS, RESTRICTIONS OR RECOMMENDATIONS.

Quackgrass *Elytrigia repens*

QUACKGRASS



JOHNSON GRASS

Quackgrass, a creeping perennial, is a very aggressive grass and is considered a noxious weed in most states. It spreads by seeds and invasive rhizomes (underground stems). Its rhizomes are yellow-white, with brown sections, and the ends are sharply pointed.

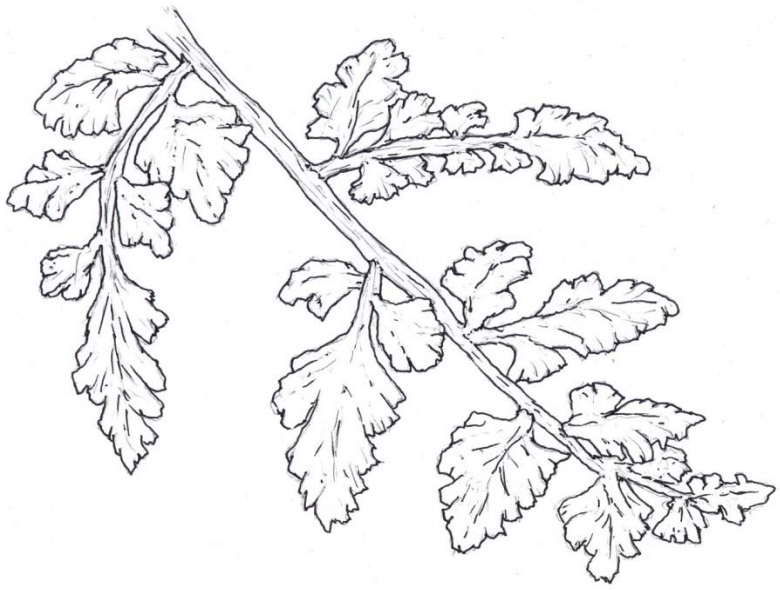
Control A few quackgrass plants can be spot-sprayed with glyphosate, or individual blades can be painted with glyphosate. Note that glyphosate will kill any bluegrass it contacts. Repeat applications to quackgrass will likely be needed. Renovate severely infested lawn areas. Spray with glyphosate; repeat applications will likely be needed. When the quackgrass has been killed, the areas may be re-sodded or re-seeded. Always read the label before applying any pesticide.

Suggested Chemical Management and control options
Bromacil + diuron (Krovar I DF)

Rate 9.6 lb ai/A (12 lb/A)
Time Apply before weeds emerge.
Remarks Rain is needed to activate this herbicide.
Caution Nonselective weed control. Do not apply to areas where desirable plant roots extend.
Site of action (bromacil) Group 5: photosystem II inhibitor; (diuron) Group 7: photosystem II inhibitor
Chemical family (bromacil) uracil; (diuron) urea

Exotic Fern Control

Japanese climbing fern is presently the only exotic invasive fern in the temperate parts of the Southeastern Region.



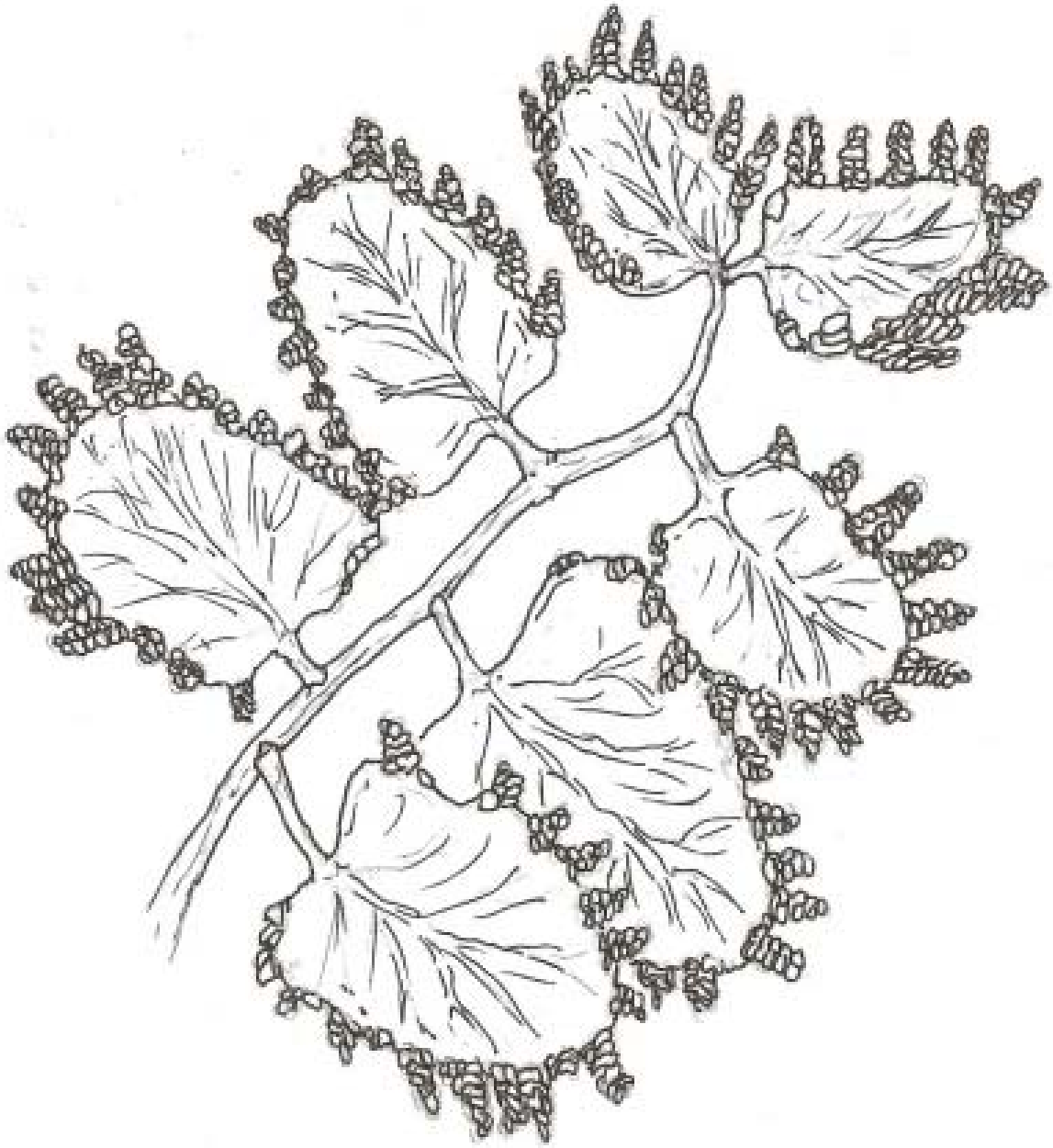
JAPANESE CLIMBING FERN

Japanese Climbing Fern *Lygodium japonicum*

Nature: Delicate viney fern with lacy finely divided leaves and green to orange to black wiry vines that climb and twine to cover and smother shrubs and trees. One of three species of climbing fern in the Southeast with the others being American climbing fern (Lygodium palmatum) and the exotic, old world climbing fern (Lygodium microphyllum) in Florida, which have once-divided leaves. All are perennial plants, from creeping rhizomes.
Origin: Native to Asia and tropical Australia and introduced from Japan.
Uses: Ornamental and stilling being spread by unsuspecting gardeners.
Herbicide Control: Apply a glyphosate herbicide, Garlon 3A or Garlon 4 as 2% solutions (8 ounces in a 3-gal. sprayer) or Arsenal AC as a 1% solution (4 ounces in a 3-gal. sprayer) in water with a surfactant to thoroughly wet all leaves in July to October. Damage to surrounding plants may occur with these herbicides, especially Arsenal, due to soil activity.

Exotic Forb Control

Forbs are broadleaf herbaceous plants. Control treatments are usually by foliar sprays of herbicides.



OLD WORLD CLIMBING FERN

Basic Broadleaf Weed Control for Home Lawns

The development and maintenance of a dense, healthy stand of grass is the best way to reduce the incidence of broadleaf weed problems developing in home lawns. To facilitate the production of healthy lawns, homeowners should incorporate recommended turfgrass selections and management practices into their establishment and maintenance programs. These recommendations include the use of adapted species and cultivars, adequate fertilization programs, proper mowing practices, adequate supplemental irrigation, and necessary insect and disease control measures. Occasionally however, even the best cared-for lawns are sometimes invaded by broadleaf weeds. To have a completely weed-free lawn, the homeowner may have to resort to the careful and selective use of broadleaf weed control herbicides.

POSTEMERGENT HERBICIDES can be used to control broadleaf weeds (i.e., non-grassy weeds) that are not prevented with the use of preemergent herbicides. It is essential that sensible cultural practices be used to encourage rapid fill-in soon after the turf has been treated with the weed control chemical, since new weeds will quickly reinfest the areas left open by the recently-killed weeds. For this reason, HERBICIDE USE SHOULD BE REGARDED AS ONLY ONE TOOL IN THE TOTAL WEED CONTROL PROGRAM.

WHICH HERBICIDE TO USE?
Before using a postemergent herbicide for broadleaf weed control, it is important to identify the weed(s) which you are attempting to control. The reason is that not all weed species are controlled via the use of one specific herbicide. The homeowner may need to use a combination of two or more herbicides to obtain the desired control. If you cannot identify the weed(s) in question, seek help from garden center personnel, or your county Extension agent.

The most readily available chemicals to homeowners for selective, postemergent control of broadleaf weeds include: 2,4- D, 2,4-DP, MCPP, and dicamba. These chemicals are available alone, and in various combinations with each other. Combination products are recommended for difficult-to-control weeds or when a variety of weed species is present in the lawn. All are available in liquid formulations (sprayable), and often in granular formulations (generally with a fertilizer) which can be applied with a drop or broadcast spreader. All of the chemicals listed above are safe for use on Kentucky bluegrass, perennial ryegrass, tall fescue, and fine fescue lawns IF THE DIRECTIONS ON THE LABEL ARE FOLLOWED. MCPP is the safest of the listed herbicides to use on bentgrass lawns.

If you decide to use an herbicide to control weeds, be sure to select the appropriate product for your situation. There are hundreds of different herbicides on the market.

Tips for selecting and using herbicides:

- Be sure to read, understand and follow all of the label directions when mixing and applying herbicides.
- Make sure the label clearly states that the product can be used in the manner you intend to use it.
- Remember, more is not better. Use the application rate on the label.
- Some herbicides are selective, and only kill certain types of plants, while others are non-selective and kill almost any type of plant.
- Some herbicides kill weeds quickly, others can take up to a week or more.
- Some herbicides persist in plants and soils for long periods of time, while others only remain in plants or soil for a short time.
- Some herbicides have active ingredients that are more likely to move through soils towards groundwater. Others are much less likely to move through soils.

WHEN TO APPLY?
Applications of herbicides intended for postemergent broadleaf weed control will only kill those weeds present at the time that the herbicide is applied. They DO NOT prevent weed seeds from germinating and developing in the lawn at a later date. It is also important to remember weeds must be actively growing when the herbicides are applied so effective control can be achieved.

This means that spring applications should be made from mid-April through early June, and fall applications should be made during the months of September and October. Herbicide applications during July and August are strongly discouraged because not only will weed control be more difficult to achieve but also an increased risk of causing damage/ discoloration to the lawn.

HOW TO APPLY?

Liquid and granular formulations of herbicides can be equally effective if they are used properly. Neither should be applied if rain is expected within 24 hours of application. For best results, the turf should NOT be mowed or watered for at least 24 hours following application of either granular or liquid products. Granular herbicides will be most effective if applied to grass that is moist (from morning dew, rainfall, or irrigation) because the granules will adhere to the wet surfaces of the weeds.

Care should always be exercised when applying herbicides near trees, shrubs, flowerbeds, and vegetable gardens. Drift from spray applications or misdirected application of granular products can result in damage or death of these plants. It is important that dicamba NOT be applied within the dripline of trees or shrubs. Dicamba can be root absorbed by these plants, possibly resulting in damage.

Weed Control	Life Cycle(1)	Recommended Chemical(2)	Time of Application	Degree of Control
Bindweed	P	2,4-D ester or dicamba(4)	early summer	good
Black medic	A	dicamba(4)	early spring	good
Chickweed, common	A	MCPP or dicamba(4)	spring or fall	good
Chickweed, mouse-ear	P	MCPP or dicamba(4)	fall or spring	good
Chickory	P	2,4-D	spring	good
Cinquefoil	P	2,4-D	fall or spring	good
Dandelion	P	2,4-D or dicamba(4)	fall or spring	good
Dock, curly	B	2,4-D or dicamba(4)	fall or spring	good
Garlic or onion	P	2,4-D ester	late fall, early spring	fair
Ground ivy	P	dicamba(4,6)	summer, fall or spring	fair-good
Heal-all	P	2,4-D	spring	good
Henbit	A	dicamba(4)	spring	good
Knotweed	A	dicamba(4,6)	spring to mid-summer	good
Mallow roundleaf	A	dicamba(4)	spring	fair
Pigweed	A	2,4-D or MCPP	summer	good
Plantain, buckhorn	P	2,4-D or MCPP	fall or spring	fair
Plantain, common	P	2,4-D or MCPP	fall or spring	good
Poison ivy	P	Amitrol-T or Roundup(5)	spring or summer	good
Purslane	A	dicamba(4)	spring or fall	good
Red sorrel	P	dicamba(4)	spring, summer or fall	good
Speedwell, creeping	P	2,4-D, MCPP or Dicamba	fall or spring	good
Speedwell, annual	A	dacthal	spring or fall	fair
Spurge, spotted	A	dicamba(4,6) or MCPP	summer	fair-good
Sow thistle	A	2,4-D or dicamba(4)	fall	good
Thistle(3)	P	dicamba(4)	spring	fair-good
Wild violet	P	dicamba(4,6) or triclopyr	spring or fall	fair-good

White clover	P	MCPP or dicamba(4)	spring, summer or fall	good
Wild carrot	B	2,4-D or dicamba(4)	fall or spring	good
Wood sorrel (Oxalis)	A	2,4-D ester, MCPP or dicamba(4,6)	early summer	fair-good
Yarrow	P	dicamba(4)	spring	fair

(1) A = Annual, B = Biennial, P = Perennial.
(2) Do not use 2,4-D on golf course greens and use with caution on other bentgrass turf.
(3) Three or more applications may be necessary to eradicate thistle.
(4) Dicamba may accumulate in the soil with frequent or extensive use which may result in damage to trees, shrubs, or other ornamentals.
(5) Nonselective herbicides. Spot treat only.
(6) 2,4-D plus dichlorprop (Weedone formulations) 2,4-D plus triclopyr (Turflon formulations) and triclopyr plus clopyralid (Confront) are effective combinations for many broadleaf weeds, including hard-to-control species such as ground ivy, wood sorrel (oxalis), spotted spurge and wild violets.

Steps should be taken to prevent erosion when using mechanical and burning treatments. For example, burning in late winter or during spring leaf-out, minimizes the period of bare soil.

An eradication program for infestations of troublesome plants usually takes several years and surveillance for many more years to check for seed germination or new invasions. Doing this in a planned manner and being persistent is the only successful strategy. In this way, land access, productivity, and native plants can be safeguarded and wildlife can continue to have suitable habitats.

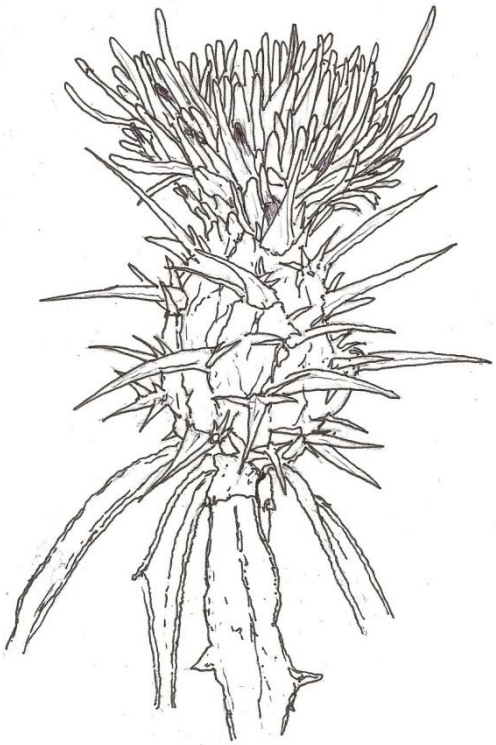
The following are herbicide prescription summaries for prevalent exotic pest plants. These prescriptions have been assembled from my published and unpublished trials, other's published research results, and reports in State and weed council's manuals, magazines, and websites (refer to list at the end). In general, very few species-specific experiments have been performed and reported that compare a full array of treatments aimed at an exotic species. But until further specific understanding is gained, we must proceed using our current knowledge and technology to combat this exotic plant invasion.

NOTE: When herbicides are used, it is the applicator's legal responsibility to read and follow directions on the product label. Not following label directions, even if they conflict with information provided herein, is a violation of federal law.

This publication contains pesticide recommendations that are subject to change at any time. These recommendations are provided only as a guide. It is always the pesticide applicator's responsibility, by law, to read and follow all current label directions for the specific pesticide being used. Due to constantly changing labels and product registration, some of the recommendations given in this writing may no longer be legal by the time you read them.

If any information in these recommendations disagrees with the label, the recommendation must be disregarded. No endorsement is intended for products mentioned, nor is criticism meant for products not mentioned. The author and Technical Learning College (TLC) assume no liability resulting from the use of these recommendations.

RUSSIAN KNAPWEED



PURPLE STAR THISTLE

CANADA THISTLE

DIFFUSE KNAPWEED

Topic 3 Commonly Found Invasive and/or Noxious Weeds
Post Quiz Answers at the rear of Glossary

Fill-in-the-blank

1. Seedlings normally emerge early in spring, develop into rosettes and spend the first season in this growth stage. Seedling emergence also can occur in fall. All seedlings grow into rosettes and _____in that stage.

2. _____has very large bracts beneath flowers that are armed with sharp spines and shoots beneath flowers are almost devoid of leaves.

3. Musk thistle will not tolerate tillage and can be removed easily by severing its root below ground with a shovel or hoe. Mowing can effectively reduce _____if plants are cut when the terminal head is in the late-flowering stage. Gather and burn mowed debris to destroy any seed that has developed.

4. Management of _____can be achieved through hand-cutting, mowing, controlled burning, and chemical means, depending on the level of infestation and the type of area being managed. Due to its perennial nature, entire plants must be killed in order to prevent regrowth from rootstock. Hand-cutting of individual plants or mowing of larger infestations should be conducted prior to seed set and must be repeated until the starch reserves in the roots are exhausted.

5. _____offers a highly promising management tactic for leafy spurge. The U.S. Department of Agriculture has shown success using six natural enemies of leafy spurge imported from Europe.

6. Mechanical and chemical methods are the most effective options currently available for_____. Hand pulling is impractical due to lespedza's extensive perennial root system. Mowing plants in the flower bud stage for two or three consecutive years may reduce the vigor of lespedeza stands and control further spread.

7. Purple loosestrife is an erect perennial herb in the loosestrife family, with a square, woody stem and opposite or whorled leaves. Leaves are lance-shaped, stalkless, and heart-shaped or rounded at the base. Plants are usually covered by a_____.

8. _____is a highly aggressive, fire-adapted colonizer that readily outcompetes native plants and rapidly reestablishes after burning. In Hawaii, where it alters the natural fire regime, fountain grass is a major threat to some critically imperiled plant species and natural communities.

9. Common mullein, also known as wooly mullein, is an erect herb in the_____. First year mullein plants are low-growing rosettes of bluish gray-green, felt-like leaves that range from 4-12 inches in length and 1-5 inches in width.

Introduction to Grasses
Exotic Grass Control

10. Exotic grasses continue to spread and increasingly reside along highway right-of-ways and thus gain access to adjoining lands. Most exotic grasses are_____, increasing fire intensities while promoting their spread after wildfire or prescribed burns, with wildland firefighters subjected to increased risks.

WITCHWEED

Topic 4 Herbs and Related Invasive Species

Common Herb Identification Terms

Alternate-leaves that are arranged singly up the stem; not opposite each other.
Annual-plant that germinates, flowers, seeds, and dies during one growing season.
Anther-structure in a flower in which pollen is formed
Auricle-lobe-like structure at the collar of a grass leaf.
Awn-slender bristle at the tip of grass seed structures.
Axil-the angle formed between a leaf and a stem.
Basal-at the base of a plant or plant part.
Biennial-plant that germinates in one growing season, then flowers, seeds, and dies during the next year.
Bract-leaf-like structure at the base of flowers or leaves.
Calyx-all the flower leaves together, normally green in color.
Clasping leaves-leaves that appear to wrap around the stem at their base.
Compound leaves-leaves with 2 or more distinct leaflets.
Cotyledons-the first leaf-like structures that appear after germination; seed leaves.
Crown-the structure formed where leaves, stems, and roots grow together.
Dissected-deeply and repeatedly divided into smaller parts.
Entire-not toothed or otherwise cut.
Glumes-the 2 bracts surrounding a grass spikelet.
Head-a group of flowers borne tightly together.
Leaflets-leaf-like structures within a compound leaf.
Ligule-the structure at the collar of a grass leaf between the sheath and the stem.
Linear-long, narrow, and slender.
Lobed-a cut into a leaf from the edge toward the center; greater than toothed, but not quite compound.
Margin-the edge of a leaf.
Membranous-thin and flexible, usually not green.
Midrib-the center and usually most prominent vein on a leaf.
Nodding-a flower that is not pointed upward, but bent downward or sidewise to the stem.
Opposite-leaves situated directly across the stem from each other.
Ovate-egg shaped in outline.
Panicle-a much-branched inflorescence.
Perennial-a plant that lives for more than 2 growing seasons.
Petiole-a leaf stalk.
Pinnate-with 2 rows of leaflets, like a feather.
Plume-a hair-like or feather-like structure, often on a seed.
Pubescence-the hairs on a leaf, stem or flower.
Rhizome-a creeping, underground stem.
Rosette-a circular, normally basal, clump of leaves.
Sheath-the extension of leaf tissue surrounding a stem.
Simple leaf-one with a blade in one piece; not compound.
Spike-a narrow, non-spreading inflorescence.
Spikelet-a single or group of floral structures in a grass.
Spur-a hollow appendage on a flower.
Stolon-a creeping stem along the surface of the ground.
Succulent-fleshy and juicy.
Taproot-a thick, central root with minimal branching.
Trifoliate leaf-a leaf made of 3 leaflets; clover-like.
Whorled-3 or more similar structures, arranged as spokes on a wheel.

Index of Poisonous Plants

Aconite	**Cherry Laurel**	**Hemlock**	**Nux Vomica**
Apple (Balsam)	**Clematis**	**Hemlock, Water**	**Paris, Herb**
Apple (Bitter)	**Coca, Bolivian**	**Hemp, Indian**	**Poppy, White**
Baneberry	**Cocculus, Indicus**	**Ignatius Beans**	**Saffron, Meadow**
Bloodroot	**Dropwort, Hemlock Water**	**Ivy, Poison**	**Spurges**
Bryony, Black	**Foxglove**	**Laburnum**	**Stavesacre**
Bryony, European White	**Gelsemium**	**Laurel, Mountain**	**Strophanthus**
Bryony, White	**Hellebore, Black**	**Lovage, Water**	**Thornapple**
Cabbage Tree	**Hellebore, False**	**Mescal Buttons**	**Wake Robin, American**
Calabar Bean	**Hellebore, Green**	**Nightshade, Black**	**Yew**
Calotropis	**Hellebore, White**	**Nightshade, Deadly**	

Green Hellebore, beautiful and deadly

* Castor beans which yield ricin and are poisonous but also have a medicinal purpose such as antifungal, cathartic, and purgative agents.

Poisons & Antidotes

In all cases of poisoning by substances taken by way of the stomach there are five indications for immediate treatment.

1. Act quickly. Call 911.
2. Empty the stomach by lavage or emetic - the first even if the poison itself has caused vomiting, but not the second when corrosives have been taken.
3. Neutralize by the appropriate antidote whatever remains in the stomach, despite emetics or lavage, bearing in mind that some poisons are secreted again in the stomach after having been absorbed.
4. Aid elimination by the bowels and kidneys of what has been absorbed.
5. Treat the condition resulting from the action of the poison.

The giving of whites of eggs is useful in most cases of poisoning, and tannin is antidotal to all alkaloids.

Biennial Herbs

Angelica - Attractive, tall, back of border plant that can grow 6-8 feet tall. The entire plant is edible and has a celery-juniper-musk smell and a licorice taste. Seeds are used in baking, and leaves can be used in salads. Roots are used in soups and stews. It is mainly used medicinally today for bronchial and digestive problems.

Caraway - Useful mid border plant with feathery leaves and cream white flowers. Roots can be cooked like parsnips, seeds are used in baking, and leaves can be added to salads. Medicinally mostly used for digestive and flatulence problems.

Evening Primrose - This useful, easy to grow back of border plant has lemon yellow flowers that open in early evening and close around mid-day. The plant is edible root to top, with a pleasant mild lemon-pepper taste. Medicinally, this is an important herb, with unique properties only found in a few other plants, providing well-documented relief for a wide variety of common ailments.

Foxglove - Tall, dramatic, and a beneficial insect magnet, Foxglove is an outstanding addition to any ornamental garden. Don't even think about using it for food or medicine, because it is highly toxic. Though it is a valuable herb medicinally, it's to be avoided at all costs by amateurs because ingesting even small amounts can be deadly.

Parsley - Considering its excellent form, easy growth requirements, and nutritional and medicinal qualities, it's a surprise that we don't see Parsley growing everywhere. It is rich in vitamins and minerals and is used medicinally for a variety of conditions. It also lends itself well to cooking and is used worldwide in a wide variety of dishes.

Foxglove

Caraway

HEMLOCK

DANDELION

Annual Herbs

Aloe Vera - Excellent indoor or outdoor container plant. Well-known and well-researched medicinal plant.

Arugala - Mustard-like green. Grow in salad gardens and use in salads and stir-fries for a peppery, pungent taste reminiscent of horseradish.

Basil - Popular, attractive plant with many color variations. No herb garden is complete without it. Excellent in salads and as a garnish. Medicinally used mainly for its stomach soothing qualities.

Borage - Attractive blue star-shaped flowers, but rather scraggly growth habit. Cucumber-like taste. Used medicinally internally in teas or topically for a variety of ailments.

Calendula - Cheerful yellow flowers that bloom almost constantly in warm weather. Excellent addition to flower or herb gardens. Flowers often used as a garnish. Limited medicinal qualities.

Cayenne - Attractive shrub-like plant with fruits that start green and then turn fiery red. Very hot, but nutritional powerhouses. Used medicinally for a variety of ailments.

Chamomile - Member of the daisy family with daisy-like flowers. Bitter taste and not usually used in cooking. Medicinal properties are well-known and include many common ailments.

Chervil - Close relative of Parsley, used mostly for flavoring other foods. Some medicinal uses, most notably for high blood pressure.

Coriander - Another member of the Parsley family. Entirely edible plant with a strong taste often used in Indian and Asian foods. Medicinally used mostly as a flavoring agent.

Dill - Popular garden herb with feathery silver green leaves. Nice addition to the herb garden. Used as a flavoring for many dishes and in pickling. Not a major medicinal herb, but often used for its stomach-soothing qualities.

Garlic - Onion-like plant with beautiful flowers. Well-known in cooking. Medicinally important herb that is completely safe. Widely available in many forms.

Savory (Summer) - Attractive trailing plant. Nice in containers. Mostly a culinary herb used in a wide variety of dishes. Tastes like peppery Thyme. Minor medicinal herb.

Arugala

Perennial Herbs

Aloe - Wonderfully easy plant to grow with amazing skin-soothing and healing properties right off the plant. Grows with little care and needs only infrequent watering. A must for every windowsill gardener and a welcome addition to the backyard herb garden. Must be brought in when the weather turns cold.

Angelica - Very tall back of the border plant (up to 8 feet in perfect growing conditions). It has a celery smell and a licorice taste, and is used widely in cooking and baking. Safe from root to leaf, this attractive plant is used medicinally mostly for bronchial problems.

Bay Laurel - Finicky ornamental tree that only does well outdoors in mild climates. Can be grown indoors if care is taken to tend to its needs. Leaves are generally used whole for flavoring in dishes with liquid bases, such as stews and soups. Medicinally used mostly as a stomach soother and mild sedative.

Catnip - Scraggly looking plant with pretty pink flowers that attract bees. Mostly used as a recreational substance for pet cats but the leaves can be used sparingly in salads and a tea can also be made for its soothing and calming effects. It's easy to grow and a good companion plant for other herbs and vegetables.

Chicory - Cool weather plant with rather scraggly overall habit, but attractive blue flowers. The ground root is a well-known coffee additive, but the roots can also be harvested and cooked like parsnips. It has a tart, bitter taste the leaves can be used in salads. Easily started from seed. Medicinally, can be used as a digestive aid and topically as a soothing eye wash.

Chives - Charming and useful member of the onion and garlic family. Cheery flowers borne on hollow, cylindrical stems. Wonderful addition to baked potatoes and many other vegetables. Good companion plant for other herbs and vegetables and a must for the windowsill herb garden. Medicinally, have the same properties as onions and garlic.

Cornflower - Wonderful, easy to grow tall plant with sky blue flowers. Easy to grow and with long, sturdy stems, this is an excellent addition to cut flower arrangements. Flowers can also be dried in silica gel or hung upside down for dried flower arrangements and crafts. Flowers are safe for consumption but rather bland. Not well studied medicinally, but may have mild antiseptic properties.

Dandelion - Largely considered a weed by homeowners, this much maligned plant has remarkable nutritional value and is safe for consumption from root to flower. Can be gathered and cooked like any other green such as turnip for a tasty, healthy addition to meals. Medicinally effective both internally and externally for a variety of ailments.

Echinacea - Hardy, easy to grow, extremely useful plant with delightful flowers on long, sturdy stems. Though it has no uses in the kitchen, it is a well-studied medicinal herb that can be safely used for a variety of ailments. A must for any serious herb garden, and a welcome addition to both formal and informal flower gardens.

Fennel - Close relative of Dill, this tall (6 foot) plant makes a nice, feathery back of border plant. It is drought-hardy and needs little care once established, and has a myriad of uses in the kitchen. Ecologically, it is a host for swallowtail butterflies, and as such should definitely be a part of any habitat-type situation. Medicinally, Fennel is well known and completely safe, and can be used in a variety of ways for relief of multiple complaints.

Feverfew - This member of the Daisy family has a very bitter taste and a smell that bees hate, making it a good plant for areas where you don't want bees to congregate such as decks and entryways. Because of the bitter taste, it has no uses in the kitchen but does appear to have some medicinal properties both internally and externally including as a digestive aid and for minor skin complaints such as stings and bruises.

Ginkgo - The Ginkgo is an amazing medium to large specimen tree that has survived since the dinosaur age. It grows into stately shade tree with distinctive fan-shaped leaves that turn a showy yellow in the fall. Ginkgo has no uses in the kitchen but is an extensively studied medicinal herb that appears to be something of an anti-aging agent, improving mood, mental alertness, memory, and stamina.

Ginseng - Tough to grow and not an ideal landscape plant, Ginseng has been over-harvested in the wild and is an endangered plant in most areas today. Most of the prepared Ginseng in the stores is commercially cultivated currently. Valued for centuries for the root that often takes on vague human shapes, the sweet-bitter taste of Ginseng is used in many oriental dishes and is considered medicinally valuable in a variety of ways, but is probably best known for its purported aphrodisiac properties.

Goldenseal - Like Ginseng, Goldenseal is difficult to grow and has only limited uses in the home landscape. It is also on the endangered list due to over-harvesting in the wild, and can be toxic when overused medicinally. It has an unpleasant bitter taste, and is best known medicinally for its supposed drug masking effects for hiding marijuana usage, which in actuality it does not do. Historically it has been used mainly as an eyewash and mouthwash, and is often included as an ingredient in Echinacea cold preventative herbal medications.

Green Tea (Camellia Sinensis) - A true heavyweight in the herbal world, it's hard to say enough about this shrub and its medicinal qualities in such a small space. The sinensis variety is the type used for green tea, and there is a remarkable list of ailments that this tea is believed to alleviate. Even if you don't grow your own plants, green tea is readily available on grocery store shelves, and virtually everyone without contraindications should at least try this amazing and easy herbal remedy at some point in their lives for the overall health benefits.

Ground Ivy - Invasive member of the mint family, this plant can take over a whole yard in a matter of a couple of years if left unchecked. It has a pleasant minty scent when crushed and inconspicuous violet flowers. It has been used for centuries as a flavoring, clarifier, and preservative for beer, and is a mild and safe herb used by herbalists for many ear, nose, throat, and digestive complaints, especially in children.

Horehound - Another member of the mint family, this is an easy to grow plant that self seeds readily and may become invasive if left to its own devices. It has a musky odor when brushed, and a menthol type taste that lends itself to flavoring for sweets and teas. Medicinally, it has been verified to work as a safe (in moderation) cough suppressant and expectorant.

Hyssop - Yet another member of the large Mint family, Hyssop is an easy to grow, attractive herb that makes a useful border or edging plant. It attracts hummingbirds, bees, and butterflies, and as such is a valuable addition to a habitat-type situation. It has a minty-licorice taste and a strong camphor-like smell. It has been used for cleansing herb since biblical times. Studies show that it does indeed have antiseptic and antiviral properties, and it is therefore of use both internally as a tea and externally for bruises, scrapes, etc.

Lantana - Lantana is a well-known landscape plant with easy culture and reliable bloom all summer long. It mingles well in flower beds and works well in containers and even on slopes for erosion control. Bees and butterflies love it, making another good addition to habitat gardens. It has no uses in the kitchen and the green berries are toxic and should be avoided. The medicinal properties are not well researched and are conflicting, however, a tea can be made from the leaves that some report is of benefit for joint pain and some flu-like symptoms.

Lavender - What can one say about Lavender? It's arguably one of the best known flower, herb, craft, and aromatherapy plants on the planet. It is versatile, relatively easy to grow, and fits into almost any garden scheme. It does equally well in containers and in the ground, and the fragrance evokes fond memories in almost everyone. It has limited use in the kitchen, but is medicinally reported to have antiseptic, anti-bacterial, anti-fungal, anti-inflammatory, anti-convulsive, and anti-depressant properties, making it a valuable medicinal herb in addition to its place in the flower and fragrance gardens.

Lemon Balm - Easy to grow, attractive, low-growing plant with a lemony-minty taste that lends itself well to many drinks and dishes. Medicinally safe and mild, usually taken in a tea for the calming and overall health benefits. Great starter plant for beginning herb gardeners and a mainstay in culinary gardens.

Lemongrass - A mainstay in southeastern Asian cooking, the grass-like foliage and lemony fragrance make this a nice addition to any herb garden. Lemongrass is an ingredient in many citronella mixtures and has known insect repellent properties. Medicinally, it is used for a plethora of complaints both internal and external. It lends itself well to the making of teas, oils, ointments, and capsules and is safe to use in moderation for most adults.

Lovage - Tall, dramatic, back of the border herb that smells and tastes like celery. In the kitchen it can be used as a substitute for celery in any dish, and it mixes especially well with potatoes and steamed vegetables. Medicinally, it is used mainly for digestive problems internally, and externally for minor skin irritations.

Marjoram - An excellent culinary herb with a cascading, mounding habit, making it a nice addition to any herb garden. Marjoram tastes like mild oregano, and can be used as an oregano substitute in any dish. Medicinally, this is a safe plant to use both internally for a variety of problems, and externally as a wash and mild pain reliever.

Mint - The mints we are most familiar with are only a small part of a huge family of plants, many of which are quite invasive. An important source of menthol and flavoring in industry, mint is also a delight in the home garden when grown in pots or otherwise contained in the garden. This rampant grower comes in a variety of flavors from strong to mild, and lends itself well to many uses in the kitchen. Medicinally, the plant is completely safe and is best known as a digestive aid. Don't forget to pick a leaf and crush it between your fingers for some of the best aromatherapy around!

Oregano - This is a nice plant with either low, sprawling growth or an upright habit, depending on the type. The hot, peppery taste lends itself to many foods beyond the obvious Italian dishes it is best known for. Oregano has not been extensively studied medicinally, but is safe for consumption and is reported to be effective in a variety of minor medical complaints, such as digestion, bloating, flatulence, coughs, and headaches, to name a few.

Periwinkle - Vining types of Periwinkle can be a Godsend in problem areas in the home landscape. This plant does well in average soil and just a little bit of shade and sports lovely blue, white, or pink flowers in spring, sporadically through the summer, and sometimes even in fall. The leaves are dark green, glossy, and evergreen and the plant grows quickly, forming an evergreen mat that quickly crowds out undesirable weeds. Rosy Periwinkle is a close relative but is sold as an upright bedding plant. It does well in hot, dry areas and provides color in areas where other plants would not survive. Medicinally, all Periwinkles have the capacity to be very poisonous, and it is not recommended that the average person make any herbal remedies from this plant.

Plantain - This plant is a tough survivor that most of us are very familiar with. It grows in sidewalk cracks, lawns, flower beds, roadsides and in waste areas and propagates itself very freely. It has a long taproot that will grow a new plant even if all the foliage is completely cut off. Many consider it Enemy #1 when they are doing battle with it in the middle of their manicured lawn. What most of us don't know, however, is that this is a versatile medicinal herb that has been well-known for centuries and is completely safe. Next time you are out mowing the lawn and get stung, grab a plantain leaf and rub it on the sting. You will never look at this "weed" in the same way again!

Poppy - This time tested gardening favorite provides interesting flower buds, showy blooms, fascinating seed pods, and incredibly easy care, with many varieties and colors to choose from. With such virtues, it's a wonder we don't see this plant in every home landscape. Medicinally, the Opium Poppy is an important medicinal herb commercially, but is a controlled plant because it is the source of most commonly known as opium. Other poppy types are also great garden plants but are only minor medicinal plants that are perfectly legal and can be used for a few common medical complaints.

Rosemary - Top of the line aromatherapy herb that can grow into a 6 foot aromatic shrub or be contained to fit proportionately in any size container. Very amenable to topiary techniques and a popular plant at Christmastime shaped like a Christmas tree and decorated. Excellent companion plant. Valuable in the kitchen for its piney-minty-ginger combination of flavors that lends itself well to meats, fish, cheese, eggs, and vegetables. Medicinally safe and can be used to treat many common ailments and also as a general tonic.

Sage - Nice looking plant with gray-green leaves that are slightly hairy. Welcome addition to herb or ornamental gardens, as the leaf color compliments other plants, especially those that are red and orange in color. Very attractive to bees, and as such a good addition to habitat-type situations. Lemony-camphor-bitter taste is well known in the kitchen as an ingredient in poultry stuffings, but also makes a nice addition to meats, poultry, and vegetables. Medicinally safe herb for a variety of medical conditions. Top notch aromatherapy herb - pick a leaf and roll it between your fingers for a remarkable aromatherapy experience.

St. John's Wort - Short-lived, opportunistic plant that has naturalized virtually all over the world. 3 foot bushy growth type with cheery bright yellow flowers that bloom in the heat of the summer while other plants are on the decline. Very easy culture, with bluish green leaves with a turpentine-like smell. Bitter taste and of no real use in the kitchen, but well-known for its anti-depressant properties medicinally.

Savory (Winter) - Woody shrub with bright green leaves and a piney flavor. Quite winter hardy and tolerates less than perfect soil. Good windowsill herb. Used mainly for seasoning game meats and in stews. Especially good for seasoning dried beans. Not currently used medicinally.

Scented Geranium - Wonderful little plant with showy leaves, delightful flowers, and aromatic properties including a variety of different scents, making this a very worthwhile garden or houseplant. Easy culture and propagation make it even better. Used in the kitchen for flavoring tea, biscuits, jelly, and even sugar. Medicinally, the plant has astringent properties, making it useful in day to day basic beauty routines.

Tansy - Good looking plant with feathery leaves and cheery yellow flowers. Pleasant piney scent when brushed against, and makes a good entryway plant for this reason. Has a strong peppery taste and can be used as a pepper substitute, but only in moderation, as it can cause extreme reactions when overdone. Medicinally, it does have useful properties, but it is not recommended that amateurs use this particular plant medicinally at all due to the adverse reactions it may cause.

Tarragon - Tarragon is not one of the more beautiful herbs, but for those who relish the anise-like flavor, it is a good addition in the herb garden nonetheless. It is a delightful enhancement to many meats and vegetables, in addition to cream sauces, vinegars, herbed butters, and yogurt. Medicinally, it can be made into a tea or dried and used in capsules for a variety of common ailments.

Thyme - Thyme is an incredible culinary herb that should be present in every garden. There are multiple varieties, from tiny plants that will fit between brick pavers to cascading types that are perfect for containers or windowsills. In cooking, it blends well with dozens of foods and other herbs. If there is a perfect culinary herb, Thyme is that herb. Medicinally, it is believed to work as an antiseptic, antifungal, and anti-parasitic.

Uva Ursi - This well-known culinary and medicinal herb is also a hard-working evergreen ground cover that thrives in poor soil and harsh conditions. The leaves are shiny and leathery, and turn a nice bronze color in the fall. Flowering occurs in late spring with bright red berries following in the fall. It generally likes cooler zones but can be grown in containers for those in the hotter areas. Berries are similar to cranberries, and can be substituted for cranberries in any dish. Medicinally, the leaves are used mostly for urinary tract type problems. There maybe contraindications to using Uva Ursi, so be well-informed before taking any homemade remedies made from this plant.

Valerian flower and roots

Valerian - Valerian is a well-known plant world wide for its anti-depressant, and tranquilizing effects. An attractive plant to look at, Valerian unfortunately smells of dirty socks, so it's definitely not a plant to put on the front step. For this reason, it is also not a culinary herb. Medicinally, however, it is one of the better known herbs for its sedative and sleep-inducing effects that many people swear by. There maybe contraindications to taking preparations containing Valerian, with prescription medicines or over-the-counter drugs, so do be informed if you intend to utilize this herb.

Violet - Violets are a delightful herb used in both cooking and medicine. They have dark green kidney or heart-shaped leaves and pretty purple fragrant flowers. They spread readily under the right conditions and can make a nice ground cover. Planted in drifts, they are a beautiful sight in the spring. Violets have been used for centuries in cooking and garnishing foods. The taste is mildly sweet. Most of us have heard of candied violet flowers and violet water. Medicinally, Violets are safe in moderation and are thought to provide relief for surprising number of common ailments, as well as possibly helping to fight tumors and cancer.

Invasive Herb Species

Some members of the herb family are known to become quite invasive when planted in and amongst other herbs in the garden. These herbs quickly will choke out their more docile garden companions and take over. Many of the invasive herbs are quite attractive and useful in the home garden, and as long as they are watched carefully, can coexist peacefully with their neighboring plants. Invasive plants are well-named: Just one small plant can turn quickly into an army that invades and conquers your whole garden. You'll find invasive plants among ornamentals, herbs, and climbers (vines).

Climbing and clambering invasives are especially notorious for exterminating everything in their path. Kudzu *(Pueraria lobata)*, which the Chinese use to treat alcoholism, is known as “the vine that ate the South” for good reason. English ivy *(Hedera helix)* and wild grape *(Vitis spp.)* are two more vigorous vines that are used medicinally — ivy for controlling skin problems, grape as a diuretic — but both may be prescriptions for trouble in your garden.

List of Highly Invasive Commonly Used Herbs

- **Artemisia *(Artemisia spp.)*:** Gardening books advise dividing this herb to create more. But artemisia, famous for thriving in poor soil, multiplies so rapidly on its own that you’ll need a calculator to add them up.
- **Comfrey *(Symphytum officinale)*:** Notice that Symphytum has the same root as the word sympathy. You’ll get neither sympathy nor comfort from comfrey when your plants multiply.
- **Costmary *(Chrysanthemum balsamita)*:** Rarely found in the wild, but in the garden, it increases fast enough to supply an entire city.
- **Fennel *(Foeniculum vulgare)*:** The seeds taste like anise, its leaves like dill. But watch out! Fennel has invaded farm fields in California and Virginia, where it’s now officially herbus non grata.
- **German, or** annual**, chamomile *(Matricaria recutita)*:** This herb self-sows almost anywhere. In Boulder, Colorado, chamomile sprouts in sidewalk cracks, a pleasant alternative to crab grass.
- **Herb-Robert *(Geranium robertianum)*:** Long associated with snakes, this plant slithers through the garden with ease, popping up where you least expect — or want — it.
- **Horseradish *(Armoracia rusticana)*:** You’re likely to leave behind a few bits of root when you dig horseradish, and every bit will turn into a new plant. Once you have it, you have it.
- **Mint *(Mentha),*** all types: No self-respecting herb garden is complete without some type of mint, but pulling, digging, or tilling this ground-spreader may mean more plants, not fewer. To keep mint under control, grow it in deep, bottomless containers, either aboveground or sunk in the garden.
- **St. John’s wort *(Hypericum perforatum)*:** St. John’s wort is an herbal mood-lifter with a reputation for getting wildly out of hand in the garden. Keep an eye on it, or you may end up depressed.
- **Tansy *(Tanacetum vulgare)*:** Tansy can repel flies, ants, and other insects, but it can also be a pest in its own right.
- **Violet *(Viola odorata)*:** Shrinking violets? Don’t believe it. One day you have a demure clump of violets, the next week you can open a flower shop.
- **Yarrow *(Achillea spp.)*:** Multiplying without help may be okay for a plant that reputedly heals bruises, burns, wounds, and sores; conditions oily hair; and looks great in dried arrangements.

Invasive herbs can be kept in check very easily simply by keeping them in individual containers, or compartments, in the garden. By keeping your invasive herbs separate, you not only keep them from choking out or taking over your other herbs and plants, but you will be assured that each of your herbs keeps their individual and distinctive scent and flavor. When different types of mint are allowed to mingle and roam freely among each other, you can wind up with them all tasting very much alike.

Even if you have a large yard or garden, that allows you the space to plant invasive herbs directly into the garden, it is recommended that you plant different types of herbs at separate ends of your garden. Otherwise, your peppermints and your spearmints will all become double-mint.

An invasive plant infestation is like a slow motion explosion, which, if left unchecked, may severely alter a site's natural, economic, aesthetic, and other cultural values. Management of invasive species while maintaining these values can appear to be a complicated and unending task.

For this reason, planning and prioritizing are crucial. By articulating clear goals, gathering the best available information, and prioritizing actions based on the significance of an infestation's impacts and feasibility of control, land managers can identify how their time, effort, and money can most effectively be applied. Invasive species present a difficult challenge with no quick and easy solutions. Many unknowns exist regarding control methods and their efficacy, in addition to limited budgets for managing invasive plants. Sometimes, the best course of action may be to do nothing.

Common Alien Plants which are used as Herbs

Goutweed (*Aegopodium podagraria*)
Garlic mustard (*Alliaria petiolata*)
Giant reed (*Arundo donax*)
Musk thistle (*Carduus nutans*)
Asiatic sand sedge (*Carex kobomugi*)
Spotted knapweed (*Centaurea biebersteinii*)
Yellow starthistle (*Centaurea solstitialis*)
Canada thistle (*Cirsium arvense*)
Leafy spurge (*Euphorbia esula*)
Cogon grass (*Imperata cylindrica*)
Chinese lespedeza (*Lespedeza cuneata*)
Purple loosestrife (*Lythrum salicaria*)
Japanese stilt grass (*Microstegium vimineum*)
Eurasian watermilfoil (*Myriophyllum spicatum*)
Burma reed (*Neyraudia reynaudiana)*
Fountain grass (*Pennisetum setaceum*)
Japanese knotweed (*Polygonum cuspidatum*)
Lesser celandine (*Ranunculus ficaria*)
Annual bastard-cabbage (*Rapistrum rugosum*)
Common mullein (*Verbascum thapsus*)

Annual bastard-cabbage

Fountain grass

Lesser celandine

Poisonous Plants and Flowers	
Common Name	Botanical Name
Aconite (wolfsbane, monkhood)	Aconitum spp.
Anemone (windflower)	Anemone spp.
Anthurium	Anthurium spp.
Atamasco lily	Zephyranthes spp.
Autumn crocus	Colchicum autumnale
Azalea	Azalea spp. (Rhododendron spp.)
Baneberry	Actaea spp.
Black locust	Robinia pseudo-acacia
Bloodroot	Sanguinaria canadensis
Boxwood	Buxus spp.
Burning bush (strawberry bush, spindle tree, wahoo)	Euonymus spp
Buttercup	Ranunculus spp.
Butterfly weed	Asclepias spp.
Caladium	Caladium spp.
Calla (calla lily)	Calla palustris (Zantedeschia aethiopica)
Carolina jasmine (yellow jessamine)	Gelsemium sempervirens
Castor bean	Ricinus communis
Cherry laurel	Prunus caroliniana
Chinaberry (bead tree)	Melia azedarach
Christmas rose	Helleborus niger
Clematis	Clematis spp.
Daffodil	Narcissus spp.
Deadly nightshade (belladonna)	Atropoa belladona
Death cammas (black snakeroot)	Zigadenus spp.
Delphinium (larkspur)	Delphinium spp.
Dogbane	Apocynum androsaemifolium
Dumbcane	Dieffenbachia spp.
Elephant ears	Colocasia antiquorum
False hellebore	Veratrum viride
Four o'clock	Mirabills jalapa
Foxglove	Digitalis purpurea

Giant elephant ear	Alocasia spp.
Gloriosa lily	Glonosa superba
Golden chain tree (laburnum)	Labunum anagryroides
Goldenseal	Hydrastis canadensis
Heavenly bamboo (nandina)	Nandinaa domestica
Henbane (black henbane)	Hyoscyamus niger
Horse chestnut (Ohio buckeye)	Aesculus spp.
Horse nettle	Solanum spp.
Hyacinth	Hyacinthus orientalis
Hyacinth bean	Dolicbos lab lab
Hydrangea	Hydrangea spp.
Iris	Iris spp.
Ivy (English ivy)	Hedera helix
Jack-in-the-pulpit	Arisaemia triphyllum
Jerusalem cherry	Solanum pseudocapsicum
Jessamine (jasmine)	Cestrum spp.
Jetbead (jetberry)	Rhodotypos tetrapetala
Jimson weed	Datura spp (Brugmansia spp.)
Jonquil	Narcissus spp.
Kentucky coffee tree	Gymnocladus dioica
Lantana	Lantana camara
Leopard's bane	Arnica montana
Lily of the valley	Convallaria majalis
Lobelia (cardinal flower, Indian tobacco)	Lobelia spp.
Marsh marigold	Caltha palustris
May apple (mandrake)	Podophyllum peltatum
Mescal bean (Texas mountain laurel, frijo lillo)	Sophora secundiflora
Mistletoe	Phoradendron spp.
Morning glory	Ipomoea violacea
Mountain laurel	Kalmia latifolia
Nightshade	Solanum spp.
Oleander	Nerium oleander
Periwinkle (myrtle, vinca)	Vinca spp.
Philodendron	Philodendron spp. (Monstera spp.)
Pittosporum	Pittosporum spp.

Poison hemlock	Conium maculatum
Potato	Solanum tuberosum
Privet	Ligustrum spp.
Rhododendron	Rhododendron spp.
Rock poppy (celandyne)	Chelidonium majus
Schefflera	Schefflera spp.
Spring adonis	Adonis vernalis
Spurge	Euphorbia spp.
Star of Bethlehem	Ornithogalum umbellatum
Sweet pea	Lathyrus spp.
Tobacco	Nicotiana tabacum
Trumpet flower (chalice vine)	Solandra spp.
Water hemlock	Cicuta maculata
Wild cherry (black cherry)	Prunus serotina
Wisteria	Wisteria spp.
Yellow allamanda	Allamanda cathartica
Yellow oleander (tiger apple, be still tree, lucky nut)	Thevetia peruviana
Yesterday-today-and-tomorrow	Brunfelsia spp.

Disclaimer: This is a list of the most common poisonous plants and flowers, but it is by no means complete. If the plant is not on this list, that doesn't necessarily make it edible or non-poisonous. Though these are listed as poisonous, they can be used in medicines or other formulations. But they must be used with care and only according to expert advice or directions. Be sure you know what you are putting in your mouth!

Jack-in-the-pulpit

Yesterday-today-and-tomorrow

Anise Hyssop

Detailed Poisonous Plants Information and Symptoms

Many plants contain poisonous substances that may be toxic to livestock if consumed. In addition, certain plants may be problematic because of mechanical irritation when eaten, photosensitization, and disagreeable tastes or odors in meat, milk, or milk products. If you suspect livestock poisoning, call a veterinarian immediately. If death occurs, the stomach contents should be examined for consumed herbage. Identify the suspected plants and remove livestock from the grazing area until all poisonous plants have been removed or destroyed. Table 2 lists some common weeds and their poisonous properties.

Table 2. Selected poisonous weeds [a]

Common name	Scientific name	Problem/symptoms	Toxic ingredient/toxicity
[a]Information taken from Fishel 2000; Hardin 1973; and Hill and Folland 1986.			
Bouncing bet	*Saponaria officinalis*	Leaves and stem—effects delayed for several days; depression, vomiting, abdominal pain, diarrhea	Saponin—amount equivalent to 3% (dry wt) of sheep wt killed within 4 hr
Buttercup	*Ranunculus* species	Leaves and stem, especially in flower; dried hay loses toxicity—anorexia, weakness, convulsions, breathing difficulty, death	Protoanemonin—toxicity reported to vary with species, age, and habitat
Cherry, black	*Prunus serotina*	Leaves (wilted leaves are worse), stems, bark, fruit—anxiety, staggering, breathing difficulty, dilated pupils, bloat, death	Cyanogenic glycosides—less than 0.25 lb leaves (fresh wt) can be toxic to 100- lb animal
Clover species	*Trifolium* species	Vegetation—hairballs; sweet clover— nose bleed, anemia, abdominal swelling	Coumarin in sweet clover—varies
Fern, bracken	*Pteridium aquilinum*	Entire plant—dullness, fever, bleeding, loss of appetite, salivation	Glycoside thiaminase—toxic to cattle fed a diet of 50% bracken fern for 30–80 days
Garlic, wild	*Allium vineale*	All plant parts—tainted milk and meat	Only toxic in large quantities
Hemlock, poison	*Conium maculatum*	All plant parts—salivation, vomiting, diarrhea, weakness, paralysis, trembling, dilation of pupils, convulsions, coma	Coniine and others—0.5 to 4% (fresh wt) equivalent of cattle wt is toxic
Jimsonweed	*Datura stramonium*	Entire plant (seeds are most toxic)— thirst, mood swings, convulsions, coma, death	Solanaceous alkaloids—0.06 to 0.09% (dry wt) equivalent of animal body wt is toxic
Locust, black	*Robinia pseudoacacia*	Leaves (especially wilted), seeds, and inner bark—weakness, depression, anorexia, vomiting, diarrhea	Phytotoxin robin, glycoside robitin—bark extract and powder in amount equivalent to 0.04 to 0.1% of animal wt toxic to horses. Cattle 10 times more tolerant.
Milkweeds	*Asclepias* species	Stems, leaves, and roots—muscle tremors, spasms, bloat, difficulty breathing	Glycosides and galitoxin—varies
Mustards	*Brassica, Thlaspi*, and *Lepidium* species	All parts (especially seeds)—oral and gastrointestinal irritation, shaking, salivation, abdominal pain, vomiting, diarrhea	Thiocyanates, irritant oils, nitrates (large quantities generally necessary for toxicity)

Table 2. Selected poisonous weeds [a]

Common name	Scientific name	Problem/symptoms	Toxic ingredient/toxicity
Nightshade species	*Solanum* species	Vegetation, unripe fruit—loss of appetite, salivation, weakness, trembling, paralysis	Solanine—toxic at 42 mg/kg (LD50)
Pigweed species	*Amaranthus* species	Foliage—kidney disease, weakness, edema, rapid respiration	Nitrates, nitrate oxalates, unknown—sheep, hogs, young calves most susceptible
Pokeweed species	*Phytolacca americana*	Entire plant, especially roots—gastrointestinal cramps, weakened pulse, respiration, salivation	Phytolacctinm—10 or more berries can result in toxicity to humans
Snakeroot, white	*Eupatorium rugosum*	Leaves and stem—constipation, loss of appetite, salivation, rapid respiration. Toxin passes through milk (milksickness).	Trophine alkaloid—varies from 1 to 20% of animal body wt. Toxin cumulative.
St. Johnswort	*Hypericum perforatum*	Flowers and leaves—photosensitivity	Hypercin—uncertain

Key points about weed forage quality and poisonous plants:

- Some weeds have excellent nutritive quality.
- Weeds in the vegetative stage of development usually are more desirable than mature weeds.
- Regardless of weed quality, livestock may avoid grazing certain plants because of taste, smell, or toxicity.
- Some plants contain poisonous substances that may be toxic to livestock if consumed. Properly identify potential problem weeds and consult with a veterinarian if necessary.

USE PESTICIDES WISELY: ALWAYS READ THE ENTIRE PESTICIDE LABEL CAREFULLY, FOLLOW ALL MIXING AND APPLICATION INSTRUCTIONS AND WEAR ALL RECOMMENDED PERSONAL PROTECTIVE GEAR AND CLOTHING. CONTACT YOUR STATE DEPARTMENT OF AGRICULTURE FOR ANY ADDITIONAL PESTICIDE USE REQUIREMENTS, RESTRICTIONS OR RECOMMENDATIONS.

NOTICE: MENTION OF PESTICIDE PRODUCTS IN THIS COURSE DOES NOT CONSTITUTE ENDORSEMENT OF ANY MATERIAL.

Edible Flowers		
Common Name	**Botanical Name**	**Comments**
Angelica	Angelica archangelica	May be skin allergen to some individuals. Good with fish and the stems are especially popular candied. Tastes like: celery-flavored.
Anise Hyssop	Agastache foeniculum	Tastes like: sweet, anise-like, licorice
Apple	Malus species	Eat in moderation; may contain cyanide precursors. Tastes like: delicate floral flavor
Arugula	Eruca vesicaria	Tastes like: nutty, spicy, peppery flavor
Basil	Ocimum basilicum	Tastes like: different varieties have different milder flavors of the corresponding leaves. Tastes like: lemon, mint.
Bee Balm	Monarda species	Used in place of bergamot to make a tea with a flavor similar to Earl Grey Tea.
Borage	Borago officinalis	Taste like: light cucumber flavor.
Burnet	Sanguisorba minor	Tastes like: faint cucumber flavor, very mild.
Calendula*	Calendula officinalis	Tastes like: poor man's saffron, spicy, tangy, peppery, adds a golden hue to foods
Carnation	Dianthus caryophyllus (aka Dianthus)	Tastes like: spicy, peppery, clove-like
Chamomile*	Chamaemelum nobile	Tastes like: faint apple flavor, good as a tea
Chicory*	http://www.henriettesherbal.com/pictures/p04/images/cichorium-intybus-1.jpg	Buds can be pickled.
Chives: Garden	Allium schoenoprasum	Tastes like: mild onion flavor.
Chives: Garlic	Allium tuberosum	Tastes like: garlicky flavor
Chrysanthemum: Garland*	Chrysanthemum coronarium	Tastes like: slight to bitter flavor, pungent

Citrus: Lemon	Citrus limon	Tastes like: waxy, pronounced flavor, use sparingly as an edible garnish, good for making citrus waters
Clover	Trifolium species	Raw flowerheads can be difficult to digest.
Coriander	Coriander sativum	Pungent. A prime ingredient in **salsa** and many Latino and Oriental dishes. Tastes like: Some palates detect a disagreeable soapy flavor while others adore it.
Cornflower*	Centaurea cynaus (aka Bachelor's Buttons)	Tastes like: sweet to spicy, clove-like
Dandelion*	Taraxacum officinalis	Tastes like: very young buds fried in butter taste similar to mushrooms. Makes a potent wine.
Day Lily	Hemerocallis species	Many Lilies (Lillium species) contain alkaloids and are NOT edible. Daylillies may act as a laxative. Tastes like: sweet, crunchy, like a crisp lettuce leaf, faintly like chestnuts or beans
Dill	Anthum graveolens	
English Daisy*	Bellis perennis	Tastes like: tangy, leafy
Fennel	Foeniculum vulgare	Tastes like: sweet, licorice flavor.
Fuchsia	Fuchsia X hybrida	Tastes like: slightly acidic
Gardenia	Gardenia jasminoides	Tastes like: light, sweet flavor
Gladiolus*	Gladiolus spp	Tastes like: similar to lettuce
Hibiscus	Hibiscus rosa-sinensis	Tastes like: slightly acidic, boiled makes a nice beverage
Hollyhock	Alcea rosea	Tastes like: very bland, nondescript flavor
Japanese Honeysuckel	Lonicera japonica	Berries are highly poisonous. Do not eat them!

Hyssop	Hyssopus officinalis	Should be avoided by pregnant women and by those with hypertension and epilepsy.
Impatiens	Impatiens wallerana	Tastes like: very bland, nondescript flavor
Jasmine Arabian	Jasminum sambac	Tastes like: delicate sweet flavor, used for teas.
Johnny-Jump-Up	Viola tricolor	Contains saponins and may be toxic in large amounts. Tastes like: sweet to bland flavor
Lavender	Lavendula species	Lavender oil may be poisonous. Tastes like: floral, slightly perfumey flavor
Lemon Verbena	Aloysia triphylla	Tastes like: lemony flavor, usually steeped for tea
Lilac	Syringa vulgaris	Tastes like: lemony, floral, pungent
Mallow Common	Malva sylrestris	Tastes like: sweet, delicate flavor
Marigold: Signet	Tagetes tenuifolia (aka T. signata)	Tastes like: spicy to bitter
Marjoram	Origanum majorana	
Mint	Mentha species	
Mustard	Brassica species	Eating in large amounts may cause red skin blotches.
Nasturium	Tropaeolum majus	Buds are often pickled and used like capers. Tastes like: sweet, mildly pungent, peppery flavor
Okra	Abelmoschus aesculentus (Hibiscus esculentus)	Tastes like: similar to squash blossoms
Pansy	Viola X wittrockiana	Tastes like: very mild sweet to tart flavor
Pea	Pisum species	Flowering ornamental sweet peas are poisonous.
Pineapple Guava	Feijoa sellowiana	Tastes like: similar to the ripe fruit of the plant, flavorful
Primrose	Primula vulgaris	Birdseye Primrose (P. farinosa) causes contact dermatitis. Tastes like: bland to sweet flavor

Radish	Raphanus sativus	Tastes like: milder, sweeter version of the more familiar radish heat
Redbud	Cercis canadensis	Tastes like: mildly sweet
Rose	Rosa rugosa or R. gallica officinalis	Tastes like: sweet, aromatic flavor, stronger fragrance produces a stronger flavor. Be sure to remove the bitter white portion of the petals. Rose hips are also edible
Rosemary	Rosmarinus officinalis	Tastes like: pine-like, sweet, savory.
Runner Bean	Phaseolus coccineus	Tastes like: nectar, bean-like
Safflower*	Carthamus tinctorius	Another "poor man's saffron" without the pungent aroma or strong flavor of the real thing
Sage	Salvia officinalis	Sage should not be eaten in large amounts over a long period of time. Tastes like: varies by type.
Savory Summer	Satureja hortensis	
Scented Geranium	Pelargonium species	Citronella variety may not be edible. Tastes like: varies with differing varieties from lemon to mint.
Snapdragon	Antirrhinum majus	Tastes like: bland to bitter flavor
Society Garlic	Tulbaghia violacea	Tastes like: a very mild garlic flavor
Squash Blossom	Cucurbita pepo species (aka Zucchini Blossom)	Tastes like: sweet, nectar flavor.
Sunflower*	Helianthus annus	Tastes like: leafy, slightly bitter. Lightly steam petals to lessen bitterness. Unopened flower buds can be steamed like artichokes.
Thyme	Thymus vulgaris	Tastes like: lemon, adds a nice light scent.

Tuberous Begonia	Begonia X tuberosa	ONLY HYBRIDs are edible. The flowers and stems contain oxalic acid and should not be consumed by individuals suffering from gout, kidney stones, or rheumatism. Further, the flower should be eaten in strict moderation. Tastes like: crisp, sour, lemony
Violet	Viola species	Tastes like: sweet, nectar
Yucca	Yucca species	Only the petals are edible. Other parts contain saponin, which is poisonous. Large amounts may be harmful. Tastes like: crunchy, fresh flavor
Flowers to Avoid	Some flowers in *particular* to be avoided (but not a complete list) are: azalea, crocus, daffodil, foxglove, oleander, rhododendron, jack-in-the-pulpit, lily of the valley, and wisteria.	
*Only the petals of these composite flowers are edible. The pollen of composite flowers is highly allergenic and may cause reactions in sensitive individuals. Sufferers of asthma, ragweed, and hayfever should not consume composite flowers, and may have extreme allergies to ingesting any flowers at all.		

Johnny-Jump-Up

Hyssop

Lilac

Master Herb Listing

COMMON NAME	OTHER NAME	SCIENTIFIC NAME	CHINESE NAME
Aloe Vera	***Sabila***	***Aloe Barbadensis Miller Liquid***	LU HUI
Alum Root	***Heuchera micrantha***	N/A	MING FAN GEN
Amara Dulcis	***Bitter-sweet, Mortal, Dogwood***	***Solanum dulcamara***	SHAN ZHU YU
Amaranthus	***Flower Gentle***	***Amaranthus 'Magic Fountain'***	XIAN SHU
American Chestnut	***Chestnut***	***Castanea dentata***	MEI SHI LI ZI SHU
American Mistletoe	***The Vampire Plant, All Heal***	***Phoradendron leucarpum***	MEI SHI HU JI SHENG
Ampalaya	***Bitter Melon***	***Momordica Charantia***	KU GUA
Anemone	***Wind Flower***	***Anemone blanda***	YIN LIAN HUA
Angelica	***Angelica hendersonii***	***Angelica archangelica***	DANG GUI GEN
Archangel	***Dead Nettle, Spotted Nettle***	***Lamium maculatum***	BAI ZHI SHU
Arrach	***Stinking Motherwort, Wild Arrach***	***Chenopodium olidum***	CHOU LI
Arssmart	***Waterpepper***	***Citrus reticulate***	SHUI LIAO
Artichokes	***Cinera***	***Cynara scolymus***	CHAO XIAN JI
Asarabacca	***Asarabacca [L,H], Asaroun [E], Azarum [E], European Ginger Root [H], Hazelwort [H], Wild Nard [H]***	***Asarum europaeum***	XI XIN MI
Ash Tree	***Common ash; European ash***	***Fraxinus excelsior***	BAI LA SHU
Asparagus	***Sparagus***	***Asparagus officinalis***	TIAN MEN DONG CAO
Atis Fruit	***Sweet Sop, Sugar Apple***	***Anonna squamosa***	FAN LI ZHI
Avens	***Colewort, Herb Bonet***	***Geum***	SHUI YANG MEI SHU
Balm	***Lemon Balm, Balm mint***	***Melissa officinalis***	XIANG FENG HUA ZHONG
Balsam Fir	***Balsam of Gilead Fir, Fir Balsam, Fir Pine, Sapin, Silver Fir, Silver Pine***	***Abies Balsamea***	XIANG ZHI LENG SHAN
Bamboo Brier	***long-stalked greenbrier, American chinaroot, false chinaroot, bullbrier.***	***Smilax pseudo-china L.***	ZU JIN JI
Barberry	***Berberis repens***	***Berberis pinnata pinnata***	OU ZHOU XIAO BO
Barley	***hato mugi***	***Hordeum vulgare***	DA MAI
Bawang	***Garlic***	***Allium Sativum***	DA SUAN
Bay Tree	***Bay Laurel***	***Laurus nobilis, Lauraceae***	YUE GUI SHU
Bayabas	***Guava***	***Psidium Guajava***	FAN SHI LIU
Bazil	***Basil***	***Ocimun basilicum***	LUO LE
Beans	***Beans***	***Phaseolus vulgaris***	DOU LEI
Bed-Straw	***Ladies Bed-Straw, Cheese-Rennet***	***Galium trifidum***	ZHU YANG YANG SHU
Beech Tree	***Beach***	***N/A***	SHAN MAO JU
Beets	***Sugar beet***	***Beta vulgaris subsp. vulgaris.***	TIAN CAI
Bifoil	***Twoblade***	***Plinius***	N/A
Big Sagebrush	***bluebunch wheatgrass Shrub Herbaceous Vegetation***	***Artemisia Tridentata***	DA SHAN AI SHU
Bilberry	***Whortleberry, Blueberry***	***Vaccinium Myrtillus***	OU ZHOU YUE JU
Birch Tree	***Cherry Birch***	***Betula alba***	BAI HUA SHU
Bird's Foot	***Alhova, Greek Clover, Greek Hay, Hu Lu Ba, Methi,***	***Fenugreek***	BAI MAI GEN
Birthroot	***Bethroot, coughroot, ground lily, Indian balm, Indian shamrock***	***Trillium Erectum***	ZHI LI YAN LIN CAO
Bishop's Weed	***Goutweed***	***Ammi***	HU GEN A MI
Bistort	***Snakeweed***	***Polygonum bistorta***	QUAN SHEN

Bitter Apple	***Colocynth Pulp. Bitter Cucumber***	***Citrullus colocynthis***	KU PING GUO
Bitter Root	***Sand Rose, Desert Rose, Rock Rose, Spatlum***	***Lewisia rediviva***	KU GEN
Black Alder Tree	***Alnus glutinosa, Betula Alnus, Common Alder, English Alder, European Alder, Owler, Tag Alder***	***Black Alder***	PU TONG CHI YANG
Black Birch	***Sweet Birch, Cherry Birch***	***Betula lenta***	HEI HUA MU
Black Cohosh	***black snakeroot, bugbane, bugwort, rattleroot***	***Cimicifuga racemosa***	HEI SHEN MA TI QU WU
Black Hellebore	***Setter-wort, Setter-grass, Bear's-foot***	***Helleborus niger* L.**	HEI TU KUI
Black Snakeroot	***Black cohosh , Black bugbane***	***Cimicifuga racemosa***	HEI SHE GEN
Black Thorn	***Sloe-Bush***	***Prunus spinosa***	LI SHU DE YI ZHONG
Blackberry Bush	***N/A***	***Rubus fruticosus***	HEI MEI GUAN MU CONG
Blue Cohosh	***squaw root , papoose root , blue ginseng , yellow ginseng***	***Caulophyllum thalictroides***	LAN SHENG MA
Blue Flag Iris	***fleur-de-lis, flower-de-luce, iris, liver lily, poison flag, snake lily, water flag, wild iris, blue flag***	***Iris versicolor***	LAN SE YUAN WEI CAO
Boneset	***Agueweed, Crosswort, Eupatorium, Eupatorium perfoliatum, Feverwort, Gravelroot, Indian Sage, Sweating Plant***	***Eupatorium Perfoliatum***	ZE LAN
Brank Ursine	***Bear's-breach***	***Acanthus***	LAO SHU LE
Briony	***Wild Vine, Wood Vine, Tamus, Ladies' Seal***		HU LU KE DE YI ZHONG MAN CAO
Brook Lime	***Water-Pimpernel***	***Veronica beccabunga***	PO PO NA ZHI YI ZHONG
Broom-rape	***Broom***	***Phyllostachys nidularia***	JIN QUE HUA
Buck's Horn	***Herb-Eve, Herb-Ivy***	***Coronopus***	XUE GEN CAO SHU
Buck's Horn Plantain	***Buck'Shorn Plantain***	***Plantago coronopus***	XUE GEN CAO SHU
Buckbean	***Bog bean***	***Menyanthes Trifoliata***	SHUI CAI
Bugle	***Sweet Bugle, Water Bugle, Gypsywort, Bugleweed***	***Ajuga reptans* L.**	XIA KU CAO
Burdock	***Loppy-major, great Burdock, Clod-bur***	***Arctium lappa***	NIU BANG SHU
Burnet	***Sanguisorbia, Bipulo, Solbegrella***	***Pimpinella***	ZANG HUI XIANG
Burnet Saxifrage	***N/A***	***Pimpinella anisum Linn.***	HUI XIANG
Butcher's Broom	***Bruscus, Kneeholm, Pettigree***	***Ruscus aculeatus***	JIA YE SHU
Butter-Bur	***Langwort, Umbrella Plan***	***Petasites***	KUAN DONG LEI
Cabbages	***Broccoli***	***Brassica rapa spp.***	YANG BAI CAI
Calamint	***Mountain-Mint***	***Calamintha nepeta***	FENG LUN CAI
California Poppy	***N/A***	***Eschscholzia californica***	HUA LIN CAO
Camomile	***matricaria, anthemis, ground apple***	***Matricaria chamomilla***	GAN JU
Campion, wild	***Evening lychnis***	***Silene latifolia-***	YE JIAN QIU LUO
Cannabis	***Hemp***	***Tetrahydrocannabinols***	DA MA
Caraway	***Wild cumin, Roman cumin***	***Carum carvi***	ZANG HUI XIANG
Carduus Benedictus	***Blessed Thistle, Holy Thistle***	***Oplopanax horridum***	FEI ZHUI
Carrots	***N/A***	***Daucus carota***	LUO BO
Cascara Sagrada	***Persian Bark, Bear Wood, Holy Bark, Christ's Thorn***	***Rhamnus purshiana***	BO XI SHU LI
Cayenne Pepper fruit	***Capsicum ,African Pepper, Chillies, Bird Pepper***	***Capsicum annuum***	LA JIAO
Celandine	***Tetterwort***	***Chelidonium majus***	BAI QU CAI
Centaury	***Feverwort, Bitter herb***	***Centaurium minus***	BAI JIN HUA SHU
Chaparral	***Creosote bush, Greaswood, Hediondilla, Larrea divaricata, Larrea glutinosa, Larrea tridentata***	***Chaparral***	XIAO KOU SHU

Cherry-Tree	***N/A***	***N/A***	YING TAO SHU
Chervil	***Sweet Cicely, Mirrha, Mirrhis***	***Anthriscus cerefolium***	XUE WEI CAI, SHAN LUO BO
Chestnut Tree	***Horsenut Tree***	***Castanea vulgaris***	XI BAN YA LI
Chickpeas	***Cicers***	***Cicer Arietinum***	JI DOU
Chickweed	***Chickwittles, Mischievous Jack, Starweed, Starwort, Winterweed***	***Stellaria media***	FAN LV
Chives	***Rush Leeks, Cives, Civet, Sweth***	***Allium schoenoprasum***	XIA YI CONG
Cinquefoil	***Five Fingers, Five-Finger Blossom, Five-finger grass, Sunkfield, Synkefoyle***	***Potentilla***	WEI LIN CAI
Clary, Wild	***Christ's Eye***	***Salvia verbenaca L.***	NAN OU DAN SHEN
Cleavers	***Bedstraw, Catchweed, Clabber Grass, Clivers, Cleavers, Coachweed, Cleaverwort, Gravel Grass, Grip Grass, Goose Grass***	***Galium aparine***	ZHU YANG YANG
Clove Gilliflowers	***N/A***	***Geum urbanum***	DING XIANG KANG NAI XING
Cock's Head	***Red Fitching, Medick Fetch***	***Astragalus agrestis***	N/A
Colchicum	***Meadow saffron***	***Colchicum* (kol-chi-cum) *autumnale***	QIU SHUI XIAN
Coleus	***N/A***	***Coleus* x *hybridus***	JING ZI SU
Colocynth (see Bitter Apple)	***See Bitter Apple***	***Citrullus colocynthis***	YAO XI GUA XIANG GUA
Coltsfoot	***Coughwort, Foals'-foot, Horse-hoof***	***Tussilago farfara***	KUAN DONG
Columbines	***N/A***	***N/A***	LOU DOU CAI
Comfrey	***Ass Ear, Black Root, Blackwort, Bruisewort, Consolidae Radix, Consound, Gum Plant, Healing Herb, Knitback, Knitbone, Salsify, Slippery Root, Symphytum Radix, Symphytum officinale, Wallwort***	***Symphytum officinale***	XI MEN FEI CAO
Common Saxifrage	***N/A***	***Saxifraga paniculata Mill.***	HU ER CAO SHU
Coneflower	***Black Sampson, Comb Flower***	***Echinacea Angustifolia***	JIN GUANG JU SHU
Coralwort	***Toothwort, Tooth Violet***	***Lathraea squamaria***	SHI ZI HUA KE
Costmary	***Alcost, Balsam Herb***	***Chrysanthemum balsamita***	JU
Cow Parsnips	***Poochki (Russian, commonly used in Alaska), Yerba del Oso***	***Heracleum lanatum***	BAI ZHI SHU
Cowslips	***Peagles***	***Primula veris***	LI JIN HUA, YE YIN CAO
Crab's Claws	***Water Sengreen, Knight's Pond Water, Water House-leek***	***N/A***	YAN ZI CAI
Cranberry	***Atoca, bearberry, bounceberry, craneberry***	***Vaccinium macrocarpon***	SUAN GUO MAN SHU, YUE JU
Cresses	***N/A***	***Lepidium sativum***	SHUI QIN
Crosswort	***Feverwort, Boneset, Agueweed***	***Boneset***	ZE LAN SHU
Crowfoot	***Gold Knobs, Gold Cups, King's Knob, Polts***	***Ranunculaceae***	MAO GEN
Cuckow-Point	***Aron, Janus, Barba-aron, Ramp, Wake Robin***	***Trillium grandiflorum***	N/A
Cucumbers	***N/A***	***Cucumis sativus***	HUANG GUA
Cudweed	***Cottonweed***	***Gamochaeta pensylvanica***	SHU QU CAO
Curly Dock	***Curled Dock, Curly Dock. Narrow-Leafed Dock. Narrow Dock. Patience Dock, Yellow Dock, Spur Dock, Bitter Dock, Blunt-Leaved Dock***	***Rumex crispus***	BAI DU CAI
Daisies	***September Flower, Monte Casino***	***Asteraceae***	CHU JU
Dandelion	***Piss-A-Beds***	***Taraxacum officinale***	PU GONG YING
Darnel	***Jam, Wray, Crop***	***Lolium temulentu***	DU MAI

Devil's Bit	***N/A***	***Scabiosa succisa***	XI YANG SHAN LUO BO
Dill	***Dill Dilly, Dill Weed***	***Anethum graveolens***	SHI LUO
Dock	***N/A***	***N/A***	LIAO KE ZHI WU
Dodder of Thyme	***Clover dodder, thyme dodder***	***Cuscuta epithymum***	TU SI ZI
Dog Mercury	***Dog's Cole***	***Euphorbiaceae***	SHAN DIAN SHU
Dog's Grass	***Couch Grass***	***Elymus repens***	MAO CAO
Dogwood	***Red Twig Dogwood, Western Dogwood, American Dogwood, Redstem Dogwood, Red Dogwood, Kinnikinnik***	***Cornus racemosa***	SHAN ZHU YU
Dong Quai	***Angelica polymorpha, Chinese Angelica, Danggui, Tang-Kuei***	***Angelica sinensis***	DANG GUI TI QU WU
Dove's Foot	***Crane's Bill***	***Geranium molle L.***	TIAN ZU KUI
Down	***Cotton Thistle***	***Onopordum***	DA CI JI
Dragons	***N/A***	***Solanum nigrum L.***	LONG KUI
Duck's Meat	***N/A***	***N/A***	N/A
Dwarf Elder	***N/A***	***Sambucus Ebulus L.***	JIE GU MU KE
Echinacea	***Coneflower***	***Echinacea***	SONG GUO JU
Egg Plant	***Deadly Nightshade, Black Nightshade***	***Solanum nigrum L.***	QIE ZI
Elaterium	***Cucumber, Squirting***	***Momordica Elaterium***	HUANG GUA
Elder	***N/A***	***Sambucus nigra***	XI YANG JIE GUO MU
Elderberry	***Elder, American Elder, Sweet Elder, Scarlet Elder, Common Elder. Red-Berried Elder, Blue-Berried Elder***	***Red Sambucus racemosa***	JIE GU MU
Elecampane	***Alant, Elf Dock, Elfwort, Horse-elder, Horseheal, Inula helenium, Pushkarmoola, Scabwort, Velvet Dock, Wild Sunflower***	***Inula helenium L.***	TU MU XIANG
Elm Tree	***Soft Elm, Water Elm***	***Ulmus***	YU SHU
Endive	***Witloof ("white leaf " in Flemish)***	***Cichorium endiva***	JU MAI CAI
English Tobacco	***N/A***	***Nicotiana tabacum L.***	YIN SHI YAN CAO
Eringo	***Sea-Holly***	***Eryngium sp.***	SAN XING HUA KE
Eucalyptus	***Eucalyptus globulus***	***Eucalyptus cinerea***	AN SHU
Evening Primrose	***Fever plant, Great Evening-Primrose, King's-cure-all, Night willow-herb, Scabish, Scurvish, Tree primrose***	***Cenothera biennis L.***	YE LAI XIANG, YUE JIAN CAO
Eyebright	***meadow eyebright, red eyebright***	***Euphrasia officinalis***	XIAO MI CAO
Fennel	***Common Fennel, Florence Fennel, Large Fennel, Sweet Fennel, Wild Fennel, Large Cumin***	***Foeniculum vulgare***	HUI XIANG
Fern	***N/A***	***N/A***	JUE LEI
Feverfew	***Featherfew***	***Tanacetum parthenium***	JU KE ZHI WU
Feverfew Leaf	***Flirtwort, Featherfoil, Bachelor's Buttons***	***Tanacetum parthenium***	XIAO BAI JU
Fig	***N/A***	***Ficus carica***	WU HUA GUO
Fig Tree (see fig)	***SEE FIG***	***SEE FIG***	N/A
Figwort	***Throatwort***	***Veronica americana***	XUAN SHEN
Filipendula	***Bridewort, Dropwort, Lady of the Meadow, Queen of the Meadow, Spirea, Spirea ulmaria***	***Meadowsweet***	XUAN GUO WEN ZI CAO
Flax Weed	***Toadflax***	***Linum usitatissimum***	YUN LAN SHU
Flea Wort	***Branched Plantain [L], Fleaseed [H], Karniyarik [E], Psyllion [H], Psyllios [H], Psyllium [E,L], Psyllium Plantain [H], Psyllium Seeds [H], Riblah [E],***	***N/A***	OU ZHOU YA MA ZI CHE QIAN

	Sand Plantain [B,H], Whorled Plantain [P], Zandweegbree [D], Zaragatona [E], Zibad [E]		
Flower-De-Luce	***Flag-lily, Fleur-de-lis, Flower-de-luce, Iris, Liver Lily, Wild Iris, Poison Flag, Flag Lily, Snake Lily***	***Iris versicolor***	YUAN WEI SHU
Fluellin	***LLUELLIN***	***Kickxia elatine***	GOU FAN LV SHU
Flux-Weed	***N/A***	***Trichostema brachiatum L.***	LI JI CAO
Fo Ti	***Chinese Knotweed, Climbing Knotweed, Flowery Knotweed, He Shou Wu***	***Polygonum multiflorum***	HE SHOU WU
Foxglove	***Witches' Gloves, Dead Men's Bells***	***Digitalis purpurea***	MAO DI HUANG
French Mercury	***La Mercurials***	***Mercurialis perennis***	FA GUO SHAN DIAN
Fuller's Thistle	***Fuller's Teasel***	***Dipsacus sativus***	LIAN RONG CAO
Fumitory	***Beggary, Earth-smoke, Drug Fumitory, Wax dolls***	***Fumaria officinalis***	YAN HU SUO SHU
Furze Bush	***Ulex europeus, Gorze, whins. Galingale***	***Ulex europeus***	JIN DOU SHU
Garden Tansy	***Tansy , garden tansy***	***Tanacetum vulgare L.***	AI JU
Garden Valerian	***garden heliotrope***	***Valeriana officinalis L.***	SHUO CAO
Garden-Patience	***Monk's Rhubarb, Yellow Dock, Curled Dock, Curly Dock, Sour Dock, Narrow Dock***	***Polygonaceae Rumex patientia***	DA HUANG
Garden-Rue	***Herb of Grace***	***Ruta graveolens L.***	YUN XIANG
Garlic	***Garlick***	***Allium sativum***	SUAN
Garlic Mustard	***Garlic Root, Hedge Garlic, Sauce-alone, Jack-in-the-bush, Penny Hedge and Poor Man's Mustard***	***Alliaria officinalis.***	SUAN JIE MO
Gentian	***Felwort, Baldmony***	***Gentiana lutea***	LONG DAN
Germander	***Camedrio, Common Germander, Germander, Germandree Petit Chene, Kamaderyos***	***Teucrium chamaedrys***	SHI CAN SHU
Ginger	***Luyang Dilaw***	***Zingiber officinale***	JIANG
Ginkgo Biloba	***maidenhair tree***	***Ginkgo biloba***	YIN XIN
Gladwin	***Stinking Gladwin***	***Iris foetidissima L.***	YUAN WEI SHU
Golden Maidenhair	***N/A***	***Ginkgo biloba 'Autumn Gold'***	YIN XIN
Golden Yarrow	***N/A***	***Eriophyllum confertiflorum***	XI YANG JING CAO
Goldenrod	***Solidago, Aaron's Rod, Woundwort, Goldrute***	***Solidago sp.***	JIA NA DA YI ZHI HUANG HUA
Goldenseal	***Yellow Root, Orange Root, Yellow Puccoon***	***Hydrastis Canadensis***	BAI MAO GEN
Gooseberry Bush	***Feapberry, Wineberry***	***Ribes rubrum***	CU LI SHU
Gotu Kola	***Brahmi, Chi-hsueh Ts'ao, man t'ien hsing, Indian Pennywort, Brahma-manduki***	***Centella asiatica***	JI XUE CAO
Goutweed	***Bishop's weed, Snow-on-the-mountain***	***Aegopodium podagraria L.***	YANG JIAO QIN
Goutwort	***Bishop's Weed, Goutweed, Goutwort, Goat-herb, Herb Gerard, Garden Plague, Snow-on-the-mountain***	***Aegopodium podagraria L.***	YANG JIAO QIN
Grape	***Holly-leaved Barberry, Oregon Grape Root***	***Mahonia aquifolia***	PU TAO
Grape Seed	***Muscat, Red Wine Extract***	***Vitis vinifera***	PU TAO ZI YOU
Great Round-leaved	***Bastard Rhubarb***	***N/A***	N/A
Green Tea Leaf	***Green Tea***	***Camellia sinensis***	LV CHA YE
Gromel	***N/A***	***N/A***	N/A
Ground Pine	***Chamepitys***	***Ajuga chamaepitys***	TU BAI
Groundsel	***Common Groundsel, Old-man-in-the-spring***	***Senecio vulgaris***	QIAN LI GUANG

Guyabano	***Soursop***	***Annona muricata L.***	CI GUO FAN LI ZHI
Hackmatack	***Tamatack***	***N/A***	DU SONG
Hart's Tongue	***Hart's Tongue Fern, Hart's Tonguefern, Hart's-Tongue Fern, Harts Tongue Fern***	***Asplenium scolopendrium***	TIE JIAO JUE
Hawk Weed	***N/A***	***Hieracium spp.***	SHUI LAN SHU
Hawthorn	***Thornapple***	***Crataegus monogyna***	DAN RUI SHAN ZHA
Hazelnut	***Filbert***	***Corylus***	ZHEN ZI
Heart Trefoil	***Birdsfoot***	***Lotus corniculatus***	MU XU
Heart's Ease	***Tansy***	***Sambucus Nigra***	SAN SE JIN
Hedge Hyssop	***N/A***	***Gratiola virginica, L.***	HAI SUO CAO SHU
Hedge-Mustard	***N/A***	***Sisymbrium officinale***	DA SUAN JIE SHU
Hemlock	***Hemlock Spruce, Canada Hemlock***	***Conium maculatum***	DU QIN, TIE SHAN
Hemp	***Marijuana***	***Cannabis sativa***	DA MA ZI
Henbane	***Insane root, stinking nightshade, fetid nightshade, hog's beam***	***Hyoscyamus niger***	TIAN XIAN ZI
Herb Robert	***Robert Geranium***	***Geranium robertianum***	QIAN XI LAO GUAN CAO
Herb True-Love	***One-Berry***	***Paris quadrifolia***	SI YE CHONG LOU
Holly	***Hulm, Holme, Holme chase, Christs thorn, Hulver bush, Bats wings, Tinne***	***Ilex opaca***	DONG QING SHU
Hops	***Stinkweed, Stinkwort, Mad Apple***	***Humulus lupulus***	PI JIU HUA
Horehound	***Hoarhound, Houndsbene, Marrubii herba, Marrubium vulgare, Mastranzo***	***Marrubium vulgare***	OU XIA ZHI CAO
Horsetail	***Bottle-brush, Dutch Rushes, Paddock-pipes, Pewterwort, Scouring Rush, Shave-grass, Toadpipe***	***Equisetum arvense***	WEN JIN
Hound's Tongue	***Dog bur, Gypsy flower***	***Cynoglossum officinale***	DAO TI HU SHU
Houseleek	***Sengreen***	***Sempervivum tectorum L.***	SHI LIAN HUA
Hyssop	***N/A***	***Hyssopus officinalis***	SHEN XIANG CAO
Indian Tobacco	***Lobelia, Pukeweed, Indian tobacco, bladderpod, wild tobacco, emetic herb, emetic weed, lobelia herb, asthma weed, rag root, eye-bright***	***Lobelia inflata***	LU DAN LI CAO
Ivy	***English Ivy***	***Hedera helix L.***	YANG CHANG XIANG TENG
Juniper Bush	***Juniper Berries***	***Juniperus communis***	OU ZHOU CI JI
Kamala	***Kamcela, Spoonwood, Rottlera tinctoria, Glandulae Rottelerae***	***Mallotus Philippinensis***	CU KANG CAI
Kava Kava	***Kava, ava, awa, ava pepper, intoxicating pepper, kawa, kew***	***Piper methysticum***	KA WA HU JIAO
Kidneywort	***Wall Pennyroyal, Wall Pennywort***	***Eupatorium spp.***	ZE LAN SHU
Knapweed	***Hardhead, Ironhead, Hard Irons, Churls Head, Logger Head, Horse knops, Matte Felon, Mat Fellon, Bottleweed, Bullweed, Cowede, Boltsede***	***Centaurea Scabiosa***	SHI CHE JU
Knapweek, black	***Black Knapweed***	***Centaurea nigra L.***	HEI SHI CHE JU
Knotgrass	***Birdgrass, Doorweed, Matgrass, Prostrate Knotweed***	***Polygonum aviculare L.***	BIAN XU
Ladies Smock	***Cuckow flower***	***Cardamine pratensis***	CAO DIAN SUI MI QI
Lady's Mantel	***Yarrow, Milfoil, nosebleed, herb militaris, soldier's woundwort, ... field hop, millefolium, old man's pepper, thousand seal, ladies' mantle***	***Alchemilla vulgaris***	YU YI CAO
Lagundi	***Five-Leaved Chaste Tree***	***Vitex Negundo***	JIN TIAO
Lavender	***N/A***	***Lavandula angustifolia***	XUN YI CAO
Lavender Cotton	***Gray santolina***	***Santolina chamaecyparissus***	MIAN XUN YI CAO

Lemon	***Citrus medica, Citronnier, Neemoo, Leemoo, Limoun, Limone***	***Citrus Limonum***	NING MENG SHU
Lettuce	***N/A***	***Lactuca sativa L.***	WO JU
Lettuce, Wild	***Wild Lettuce, Lettuce Opium***	***Lactuca virosa***	YE SHENG WO JU
Licorice Root	***Yashtimadhu, Mithi-lakdi, Mulathi, Liquorice, sweetwood***	***Glycyrrhiza glabra***	GAN CAO GEN
Lily of the Valley	***Conval lily, Male lily, Lily Confancy***	***Convallaria majalis***	LING LAN
Lime	***Citrus acris, Limettae Fructus***	***Citrus Aurantium***	YUN XIANG KE SHU
Lime Tree	***Tilia vulgaris, Tilia intermedia, Tilia Cordata, Tilia platyphylla, Linden Flowers, Linn Flowers, Common Lime, Flores Tiliae, Tilleul***	***Tilia Europoea L.***	PU TI SHU
Liverwort	***Ackerkraut, Agrimonia, Agrimonia eupatoria, Church Steeples, Cocklebur, Funffing, Herbe de Saint-Guillaume***	***Agrimony***	MING GUI XI XIN
Loosestrife	***Willow herb***	***Epilobium L. sp.***	QIAN QU CAI
Lovage	***Tadic Ligutici, Tadix Laserpitii Germanici, Levisticum, Liebstoeckelwurzel, Maggiwurzel***	***Levisticum officinale***	OU DANG GUI
Lungwort	***Spotted lungwort , Jerusalem cowslip, oak lungs, lung moss, spotted comfrey, oak lungs***	***Pulmonaria officinalis***	FEI CAO
Madder	***N/A***	***Rubia tinctorum***	XI CAO
Mangosteen	***Mangis, mangu, mangostan, mangostanier, mesetor, semetah***	***Garcinia mangostana***	DAO NIAN ZI SHU
Maple Tree	***N/A***	***N/A***	FENG SHU
Marigolds	***Caltha, Ganda, Gols bloom, Garden Marigold, Gold bloom, Holligold, Marybud, Pot Marigold***	***Tagetes sp.***	JIN ZHAN CAO, WAN SHOU JU
Marshmallows	***Althea, Mallards, Sweet Weed, Wymote***	***Althaea officinalis***	YAO SHU KUI
Masterwort	***Cow-parsnip***	***Astrantia***	OU QIAN HU
Meadow Sweet	***Mead Sweet***	***Spiraea ulmaria***	XIU XIAN JU
Meadow Trefoil	***Honey Trefoil, Honeysuckle***	***Lonicera***	RENG DONG, JIN YIN HUA
Meadow-Rue	***Muskrat weed***	***Thalictrum polygamum***	CAO DIAN YUN XIANG
Medlar	***N/A***	***Fructus Lycii***	OU ZHA
Melancholy Thistle	***N/A***	***Cirsium heterophyllum L.***	YOU YU JI
Mellilot	***King's Claver***	***Melilotus officinalis***	CAO MU XI
Milk Thistle Seed	***N/A***	***Silybum marianum***	SHUI FEI JI
Milkweed	***Silkweed***	***Asclepias***	RU CAO SHU
Mimosas	***Mimosa fragnfolia, M.linguis, M. humilis***	***N/A***	HAN XIU CAO
Mint	***N/A***	***Labiatae***	BO HE
Mistletoe	***All Heal, Bird Lime, Devil's Fuge, European Mistletoe, Golden Bough, Herb de la Croix, Lignum Crucis, Mistal, Viscum***	***Viscum album***	HU JI SHENG
Mithridate Mustard	***Hsi Ming [E], Mithridate Mustard [H], Penny Cress [E], Pennycress [H], Witte Krodde [D]***	***Thlaspi***	XI
Moneywort	***Herb Two-Pence, Creeping Jennie, Creeping Jenny***	***Lysimachia nummularia***	TONG QIAN ZHUANG ZHEN ZHU CAI
Moonwort	***Grapefern***	***Botrychium lunaria***	YIN DI JUE SHU
Morinda citrifolia	***Ba Ji Tian, Hog Apple, Indian Mulberry, Menkoedoe, Noni, Ruibardo Caribe, Wild Pine***	***Morinda***	BA JI TIAN
Morning Glory	***Grannyvine***	***Ipomoea tricolor***	QIAN NIU HUA
Mosses	***N/A***	***N/A***	TAI
Motherwort	***Lion's Ear, Lion's Tail, Throw-wort***	***Leonurus cardiaca***	WEI YI MU CAO

Mouse-Ear	***Satinflower, Starweed, Starwort, Stellaria media, White Bird's Eye, Winterweed***	***Hieracium pilosella L.***	SHAN LIU JU
Mugwort	***Artemisa, Carline Thistle, Chiu Ts'Ao, Common Mugwort, Douglas Mugwort, Felon herb, Sailor's tobacco, Wormwood***	***Artemisia vulgaris***	AI HAO
Mulberry Tree	***N/A***	***Morus loxostylus***	SANG SHU
Mullein	***Adam's Flannel, Beggar's Blanket, Candlewick Plant, Common Mullein, Flannel Mullein, Flannel Plant, Hag's Taper***	***Verbascum thapsus L.***	MAO RUI HUA
Mustard	***N/A***	***N/A***	JIE MO
Nailwort	***Whitlow Grass***	***Paronychia***	ZHI JIA CAO SHU
Nep	***Catmint***	***Nepeta grandiflora***	JIA JIN JIE
Nettle	***Stinging Nettle***	***Urtica dioica L.***	QI MA
Nightshade	***Bitter nightshade, bittersweet, blue nightshade, climbing bittersweet, climbing nightshade, deadly nightshade, dogwood, dulcamara***	***Solanum umbeliferum***	QIE SHU ZHI WU
Oak Tree	***N/A***	***Quercus robur***	XIA SHUO
Oat	***N/A***	***Avena sativa L.***	YAN MAI
Onion	***N/A***	***Allium cepa***	YANG CONG
Orchis	***Early-purple Orchid [L], Mannetjesorchis [D]***	***morio ssp.***	LAN HUA
Oregano	***Wild Marjoram, Mountain Mint, Origanum, Wintersweet, Winter Marjoram***	***Origanum vulgare***	NIU ZHI
Orpine	***Orpine Stonecrop [H], Witch's Moneybags [P]***	***Sedum telephium***	JING TIAN
Oswego Tea	***Bee Balm***	***Monarda Didyma***	XIANG FENG CAO
Our Lady's Thistle	***Cardui mariae, Carduus marianum, Holy Thistle, Lady's Thistle, Legalon, Marian Thistle***	***Milk Thistle***	OU ZHOU FEI SHUI JI
Oxalis	***Creeping woodsorrel***	***Oxalis crassipes***	CU JIANG CAO
Parsley	***Garden parsley, rock parsley, common parsley, march***	***Petroselinum crispum***	ZHOU YE SHI SHE CHUANG
Parsnips	***N/A***	***Pastinaca sativa***	OU FANG FENG
Peach Tree	***N/A***	***Prunus persica***	TAO SHU
Pear Tree	***N/A***	***Pyrus pyrifolia***	LI SHU
Pellitory of Spain	***N/A***	***Anacyclus pyrethrum***	NAN OU PAI LI TUN CAO
Pellitory of the Wall	***N/A***	***Parietaria officinalis L.***	QIAO CAO SHU
Pennyroyal	***American Pennyroyal, European Pennyroyal, tickweed, sqaw mint, stinking balm, thickweed, mock pennyroyal, mosquito plant***	***Mentha pulegium***	BO HE, OU YA BO HE
Peony	***Richesand honor flowers, Kilogramsgold***	***Paeonia officinalis***	SHAO YAO
Pepperwort	***Dittander***	***Marsilea oligospora***	HU JIAO CAO
Periwinkle	***Flat winkle***	***Vinca minor***	XIAO MAN CHANG CHUN HUA
Pimpernel	***N/A***	***N/A***	FAN QIAN HUA
Plantain	***Broadleaf Plantain, Great Plantain, Greater Plantain, Ripple Grass, Plantago Asiatica, Waybread, Waybroad, Snakeweed***	***Plantago lanceolata***	CHANG YE CHE QIAN
Plums	***Cherry, Apricot***	***Prunus***	MEI SHU, LI SHU
Polypody of the Oak	***Polypody fern***	***Polypodium vulgare***	WA WEI SHU ZHI WU
Poplar Tree	***Yellow Poplar, Tulip Wood***	***Populus spp.***	BAI YANG

Poppy	***N/A***	***Papaver spp.***	YING SU
Primrose	***N/A***	***Primula veris***	BAO CHUN
Privet	***N/A***	***Ligustrum spp.***	NV ZHEN
Purslain	***Purslane, Purslain, Prusley, Kitchen garden***	***Portulaca***	CHANG MING CAI
Quince Tree	***N/A***	***Cydonia oblongo***	WEN BAI SHU
Radish	***Horseradish***	***Raphanus sativus***	LUO BO
Ragwort	***St.James' wort, Staggerwort, Stammerwort, Segrum***	***Senecio jacobaea L.***	GOU SHE CAO
Rattle Grass, Yellow	***Yellow Rattle***	***Rhinanth minorus***	FO JIA CAO
Rest Harrow	***Cammock***	***Ononis L.***	MANG BIN HUA
Rhubarb	***Rephontic***	***Rheum rhabarbarum***	DA HUANG
Rocket	***Dame's rocket; Sweet rocket***	***Hesperis matronalis***	OU YA XIANG HUA JIE
Rosa Solis	***Sun Dew, Redrot, Youthwort***	***Drosera filiformis***	MAO GAO CAI
Rosemary	***N/A***	***Rosmarinus officinalis***	MI DIE XIANG
Roses	***N/A***	***Rosa spp.***	QIANG WEI
Rupture-Wort	***Smooth rupturewort; glabrous rupturewort***	***Herniaria hirsute***	MAO HE NI YA CAO
Rushes	***N/A***	***N/A***	YE XI CAO
Rye	***N/A***	***Secale cereale subsp.***	LUO MAI
Saffron	***Alicante Saffron, Autumn Crocus, Crocus, Gatinais Saffron, Hay Saffron Karcom, Stima Croci***	***Crocus sativa***	FAN HONG HUA
Sage	***N/A***	***Salvia officinalis***	YAO SHU WEI CAO
Sambong	***N/A***	***Blumea Balsamifera***	BIAN DOU CAI
Samphire	***Chicken claws, criste marine or pousse-pied (France), glasswort, Marsh Samphire, Meerfenchel (Germany), pickle plant, rock samphire***	***Halosarcia species***	HAI MA CHI
Sanicle	***Butterwort***	***Sanicula***	BIAN DOU CAI
Saracen's Confound	***Saracen's Woundwort***	***Senecio fluviatilis***	N/A
Sarsaparilla	***American Sarsaparilla, Bamboo Brier, Shot Bush, Spikenard, Spreading Spikenard, Wild Liquorice***	***Smilax officinalis***	BA QIA
Sauce-Alone	***Jack-By-The-Hedge-Side***	***Alliaria petiolata***	CONG JIE ZHONG
Savine	***N/A***	***Juniperus phoenicea***	SHUANG ZI BAI
Saw Palmetto	***Sabal***	***Sabal serrulata***	JU CHI ZONG
Scabious	***Cream Scabious***	***Scabiosa ochroleuca***	SHAN LUO BO SHU
Scurvygrass	***N/A***	***Cochlearia danica***	LA GEN CAI
Self-Heal	***Prunel, Carpenter's Herb, Hookheal, Sicklewort***	***Prunella***	XIA KU CAO
Seneca Snakeroot	***Seneca root, rattlesnake-root, mountain flax***	***Polygala senega***	MEI ZHOU YUAN ZHI
Service Tree	***N/A***	***Sorbus torminalis***	MEI ZHOU SHI YI SHU
Shepherd's Purse	***Whoreman's Permacety, Shepherd's scrip, Shepherd's Pounce, Toywort, Pickpurse, Casewort***	***Capsella bursa pastoris***	QI CAI
Slippery Elm	***Red Elm, Moose Elm, Indian Elm***	***Ulmaceae Ulmus rubra L***	YU SHU
Smallage	***Celery, Celery Seeds, Garden celery, wild celery***	***Apium Graveolens***	KUAI GEN QIN
Solomon's Seal	***American Solomon's Seal, King Solomon's Seal, King Solomon's-seal, Small Solomon's Seal, Lady's Seals***	***Polygonatum odoratum***	SUO LUO MEN DE FENG YIN
Sopewort	***Bruisewort***	***Saponaria officinalis***	FEI ZAO CAO
Sorrel	***N/A***	***Oxalis macrocarpa***	SUAN MO

Southern Wood	***Wormwood, absinthium, green ginger, absinthe, old woman***	***Artemisia abrotanum***	AI SHU ZHI WU
Sow Thistle	***Spiny sow-thistle, Spiny milk-thistle, Spiny-leaved sow-thistle, Spiny annual sow-thistle***	***Sonchus asper***	KU CAI
Spignel (Spikenard)	***Spikenard***	***Meum athamanticum***	SAN XING KE ZHI WU
Spirulina	***Arthrospira, BGA, Blue-Green Algae, Cyanobacteria, Cyanophyta***	***Arthrospira Platensis***	LUO XUAN ZAO
Spleenwort	***Ceterach, Heart's Tongue***	***Asplenium***	TIE JIAO JUE
St. John's Wort	***Hypericum, Klamath weed, goat weed***	***Hypericum perforatum***	GUAN YE JIN SI TAO
St. Peter's Wort	***Peterwort***	***Hypericum tetrapterum***	TENG HUANG KE
Star Thistle	***Yellow Star Thistle, Purple Star Thistle***	***Centaurea solstitialis L.***	SHI CHE JU
Stone-Crop	***Pick-Madam, Small-Houseleek***	***Hylotelephium maximum L.***	JING TIAN KE
Strawberries	***N/A***	***Fragaria viridis***	CAO MEI
Succory	***Chicory***	***Cichorium intybus L.***	JU JU
Sweet Alyssum	***N/A***	***Lobularia maritima***	XIAO BAI HUA
Sweet Majoram	***N/A***	***Origanum majorana***	MA YU LAN
Sweet Maudlin	***N/A***	***Ageratum***	HUO XIANG JI SHU
Tamarisk Tree	***Salt cedar (English), Sommertamariske (German)***	***Tamarix parviflora***	
Thistles	***Swamp thistle, Pasture thistle, Fragrant thistle***	***Cirsium muticum***	JI SHU ZHI WU
Thornapple	***Mexican pricklepoppy, Prickly poppy, Devil's Apple, Jamestownweed, Jimsonweed, Stinkweed, Devil's Trumpet, Apple of Peru***	***Datura stramonium***	MAN TUO LUO
Thorough Wax	***Thorough Leaf, Thoroughwort, Agueweed, Crosswort, Eupatorium, Eupatorium perfoliatum, Feverwort, Gravelroot, Indian Sage***	***Boneset***	GUAN YE ZE LAN
Thyme	***Common Thyme***	***Thymus vulgaris***	BAI LI XIANG
Toadflax	***Fluellin, Pattens and Clogs, Flaxweed, Ramsted, Snapdragon, Churnstaff, Drgon-bushes, Brideweed, Toad, Yellow Rod, Larkspur Lion's Mouth, Devils' Ribbon, Eggs and Collops, Devil's Head, Pedlar's Basket, Gallwort, Rabbits, Doggies, Calves' snout, Buttered Haycocks, Monkey Flower***	***Linaria vulgaris***	YUN LAN SHU
Tomato	***Golden apple, love apple***	***Lycopersicon esculentum L.***	XI HONG SHI
Treacle Mustard	***N/A***	***Erysimum repandum***	TANG JIE MO
Tsaang Gubat	***Wild Tea, Forest Tea, Slibungog, Putputai, Maragued***	***Ehretia Microphylla Lam***	XIAO YE HOU KE SHU
Turkey Corn	***Turkey Pea, Squirrel Corn, Staggerweed, Bleeding Heart, Shone Corydalis***	***Dicentra cucullaria***	HE BAO MU DAN KE
Turnsole	***Folium***	***Heliotropium***	XIANG YANG XING ZHI WU
Tutsan	***Park-Leaves, Touch-leaves, Touch-and-heal, Sweet-amber, Sweet-leaf***	***Androsaemum***	TU SAN JIN SI TAO
Valerian	***ALL-HEAL, GREAT WILD VALERIAN, AMANTILLA, SETEWALE, PHU, CAPON'S TAIL***	***Valeriana officinalis***	XIE CAO
Verbena	***N/A***	***Verbena* spp.**	MA BIAN CAO
Vervain	***Wild Hyssop, Simpler's Joy, American vervain, blue vervain***	***Verbena officinalis***	MA BIAN CAO
Vine	***English Vine***	***Ipomea quamoclit***	PU TAO SHU
Violets	***N/A***	***Violaceae***	JIN CAI KE
Viper's Bugloss	***Blue Devil, Blueweed***	***Echium vulgare L.***	NIU SHE CAO

Virginia Creeper	***American Ivy, Five-leaved ivy, Ampolopsis quinquefolia, Cissue Hederacea, Woodvine***	***Vitis quinquefolia, L.***	WU YE DI MIAN
Wall Flowers	***Winter Gilliflowers***	***Erysimum linifolium (Pers.)***	QIANG HUA
Wallrue	***White Maidenhair***	***Asplenium ruta-muraria L.***	QIANG SHENG TIE JIAO JUE
Walnut Tree	***N/A***	***Juglans regia***	HU TAO SHU
Water Agrimony	***Water Hemp, Bastard Hemp, Bastard Agrimony***	***Eupatorium cannabinum***	LONG YA CAO
Water Betony	***Brownwort, Bishop's leaves***	***Scrophularia auriculata***	SHUI SU SHU
Water Cresses	***Brooklime, Brown Cress, Cress, Cresson, Nasturtium, True Watercress, Watercress***	***Nasturtium officinale***	DOU BAN CAI
Water Lily	***N/A***	***Nymphaea odorata***	HE HUA, SHUI LIAN
Water-Caltrops	***Water Chestnut***	***Trapa natans L.***	LING JIAO
Wheat	***N/A***	***Triticum aestivum***	XIAO MAI
Wild Majoram	***Oregano, Origanum, Eastward Marjoram Wind Marjoram, Grove Marjoram***	***Origanum vulgare***	YE MA YU LAN
Wild Tansy	***Silver Weed, Hay-fever weed, bitterweed, annual ragweed, blackweed***	***Ambrosia artemisiifolia L.***	YE AI JU
Wild Thyme	***Mother of Thyme***	***Thymus pulegioides(T. serpyllum)***	BAI LI XIANG
Willow Tree	***Sitka Willow***	***Salix sitchensis***	LIU SHU
Winter Cherries	***Christmas Cherry, Ornamental Pepper, Tom Thumb***	***Solanum***	QIE SHU ZHI WU
Winter Savory	***Ajedrea, Ajedrea Fina, Bean Herb, Sariette, White Thyme***	***Satureja montana***	OU ZHOU FENG LUN CAI
Wintergreen	***Boxberry, Canada tea, checkerberry, ground Berry, mountain tea***	***Gaultheria procumbens***	DONG QING
Winter-Rocket	***Winter cresses***	***Barbarea vulgaris***	DONG SHUI QIN
Woad	***Ban Lan Gen, Ch'Ing Tai, Dyer's Woad, Dyer's-woad, Tein-ching, Tien Hua, Wede***	***Isatis tinctoria***	BAN LAN GEN
Wold	***Dyer's mignonette, dyer's rocket, dyer's weed, mignonette, weld, yellow weed***	***Reseda luteola***	HUANG MU XI CAO
Wood Betony	***Lousewort***	***Stachys officinalis***	HUO XIANG MU SHUI SU
Wood Sorrel	***Shamrock, Sleeping Beauty, Sour Trefoil***	***Oxalis***	CU JIANG CAO
Woodbine	***Honey-suckles***	***Lonicera caprifolium***	REN DONG SHU
Wood-Sage	***Wood Germander***	***Teucrium scorodonia***	SHI CAN SHU
Woolen	***Scotch thistle, acanthe sauvage, Cotton thistle, White thistle, Cotton Thistle***	***Onopordum nervosum L.***	JI
Wormwood	***Absinthium, absinth wormwood***	***Artemisia absinthium***	YANG AI
Yarrow	***Milfoil, Thousand-leal***	***Achillea millefolium***	JING
Yellow Dock	***Curly dock , curled dock , narrow dock , sour dock***	***Rumex crispus L.***	SUAN MO
Yerba Buena	***N/A***	***Mentha Spicata***	BO HE LEI

* **Citation**: NC STATE UNIVERSITY, FLORA OF DELAWARE, GARDENGUIDES, PCA ALIEN PLANT WORKING GROUP (NPS), NEW MEXICO STATE UNIVERSITY(NMSU), COLORADO WEED MANAGEMENT(CWMA), DRUGDIGEST, INVASIVE ORG., NORTH CAROLINA STATE UNIVERSITY(NCSU).

Commonly Found Invasive Herbs and Related Herb-like Plants

Many of the missing herbs are in the common weed section of this course

Alfalfa *Medicago sativa L.* Plant Symbol = MESA

Weediness

This plant may become weedy or invasive in some regions or habitats and may displace desirable vegetation if not properly managed. Please consult with your local NRCS Field Office, Cooperative Extension Service office, or state natural resource or agriculture department regarding its status and use. Weed information is also available from the PLANTS Web site at plants.usda.gov.

Description

Medicago sativa L., alfalfa, is a long-lived perennial legume. Flowers vary in color from purple to yellow and are borne in loose clusters. Pods of alfalfa range from the sickle type to those that are twisted into spirals. Each pod contains several small kidney-shaped seeds. Alfalfa's stems are erect and grow from a woody crown to about 2 to 3 feet tall. New growth occurs from buds in the crown. The plant has a tap root which may penetrate deep into the soil. Leaves are alternately arranged on the stem and are normally trifoliate.

Adaptation and Distribution
Alfalfa grows best on deep, well-drained, friable soils. Lands subject to frequent overflows or high water tables are unfavorable for alfalfa. The pH of the soil should be 6.5 or above. Alfalfa is distributed throughout the entire United States.

Establishment
A seedbed must be smooth, firm, free of weeds and trash, and contain adequate moisture for germination and emergence. Land grading must be sufficient to ensure good surface draining. Alfalfa should not be seeded as a first crop on newly leveled land where fill may settle and cause poor surface drainage. Five pounds of scarified, properly inoculated pure live seed (PLS) per acre evenly drilled ¼-inch deep on adapted, properly prepared sites will produce adequate stands. A combination drill and packer is desirable.

Ecology
Alfalfa is a perennial forage legume which normally lives four to eight years, but can live more than 20 years, depending on variety and climate. The plant grows to a height of up to 1 m (3 ft), and has a deep root system, sometimes stretching more than 15 m (49 ft). This makes it very resilient, especially to droughts. It has a tetraploid genome.

Alfalfa is a small-seeded crop, and has a slowly growing seedling, but after several months of establishment, forms a tough 'crown' at the top of the root system. This crown contains many shoot buds that enables alfalfa to regrow many times after being grazed or harvested.

This plant exhibits autotoxicity, which means it is difficult for alfalfa seed to grow in existing stands of alfalfa. Therefore, alfalfa fields are recommended to be rotated with other species (for example, corn or wheat) before reseeding.

Culture
Alfalfa is widely grown throughout the world as forage for cattle, and is most often harvested as hay, but can also be made into silage, grazed, or fed as greenchop. Alfalfa usually has the highest feeding value of all common hay crops. It is used less frequently as pasture. When grown on soils where it is well-adapted, alfalfa is often the highest-yielding forage plant, but its primary benefit is the combination of high yield per hectare and high nutritional quality.

Its primary use is as feed for high-producing dairy cows, because of its high protein content and highly digestible fiber, and secondarily for beef cattle, horses, sheep, and goats. Alfalfa hay is the most widely used fiber source in rabbit diets. In poultry diets, dehydrated alfalfa and alfalfa leaf concentrates are used for pigmenting eggs and meat, due to their high content in carotenoids, which are efficient for coloring egg yolk and body lipids. Humans also eat alfalfa sprouts in salads and sandwiches. Dehydrated alfalfa leaf is commercially available as a dietary supplement in several forms, such as tablets, powders and tea. Alfalfa can cause bloating in livestock, so care must be taken with livestock grazing on alfalfa because of this hazard.

Like other legumes, its root nodules contain bacteria, Sinorhizobium meliloti, with the ability to fix nitrogen, producing a high-protein feed regardless of available nitrogen in the soil. Its nitrogen-fixing ability (which increases soil nitrogen) and its use as an animal feed greatly improve agricultural efficiency.

Alfalfa can be sown in spring or fall, and does best on well-drained soils with a neutral pH of 6.8 – 7.5. Alfalfa requires sustained levels of potassium and phosphorus to grow well. It is moderately sensitive to salt levels in both the soil and irrigation water, although it continues to be grown in the arid southwestern United States, where salinity is an emerging issue. Soils low in fertility should be fertilized with manure or a chemical fertilizer, but correction of pH is particularly important. Usually a seeding rate of 13 – 20 kg/hectare (12 – 25 lb/acre) is recommended, with differences based upon region, soil type, and seeding method. A nurse crop is sometimes used, particularly for spring plantings, to reduce weed problems and soil erosion, but can lead to competition for light, water, and nutrients.

Beneficial insects
Alfalfa is considered an insectary, a place where insects are reared, and has been proposed as helpful to other crops, such as cotton, if the two are interplanted, because the alfalfa harbors predatory and parasitic insects that would protect the other crop. Harvesting the alfalfa by mowing the entire crop area destroys the insect population, but this can be avoided by mowing in strips so that part of the growth remains.

Pests and diseases
Like most plants, alfalfa can be attacked by various pests and pathogens. Diseases often have subtle symptoms which are easily misdiagnosed and can affect leaves, roots, and stems. Some pests, such as the alfalfa weevil, aphids, armyworms, and the potato leafhopper, can reduce alfalfa yields dramatically, particularly with the second cutting when weather is warmest. Chemical controls are sometimes used to prevent this. Alfalfa is also susceptible to root rots, including Phytophthora, Rhizoctonia, and Texas root rot.

Alfalfa and bees
Alfalfa seed production requires the presence of pollinators when the fields of alfalfa are in bloom. Alfalfa pollination is somewhat problematic, however, because western honey bees, the most commonly used pollinator, are not suitable for this purpose; the pollen-carrying keel of the alfalfa flower trips and strikes pollinating bees on the head, which helps transfer the pollen to the foraging bee. Western honey bees, however, do not like being struck in the head repeatedly and learn to defeat this action by drawing nectar from the side of the flower. The bees thus collect the nectar, but carry no pollen, so do not pollinate the next flower they visit. Because older, experienced bees do not pollinate alfalfa well, most pollination is accomplished by young bees that have not yet learned the trick of robbing the flower without tripping the head-knocking keel. When western honey bees are used to pollinate alfalfa, the beekeeper stocks the field at a very high rate to maximize the number of young bees. Western honey bee colonies may suffer protein stress when working alfalfa only, due to shortage of one of the amino acids comprising the pollen protein, isoleucine.

Today, the alfalfa leafcutter bee is increasingly used to circumvent these problems. As a solitary but gregarious bee species, it does not build colonies or store honey, but is a very efficient pollinator of alfalfa flowers. Nesting is in individual tunnels in wooden or plastic material, supplied by the alfalfa seed growers. The leafcutter bees are used in the Pacific Northwest, while western honeybees dominate in California alfalfa seed production.

A smaller amount of alfalfa produced for seed is pollinated by the alkali bee, mostly in the northwestern United States. It is cultured in special beds near the fields. These bees also have their own problems. They are not portable like honey bees, and when fields are planted in new areas, the bees take several seasons to build up. Honey bees are still trucked to many of the fields at bloom time.

Varieties
Considerable research and development has been done with this important plant. Older cultivars such as 'Vernal' have been the standard for years, but many better public and private varieties better adapted to particular climates are available. Private companies release many new varieties each year in the US.

Most varieties go dormant in the fall, with reduced growth in response to low temperatures and shorter days. 'Nondormant' varieties that grow through the winter are planted in long-seasoned environments such as Mexico, Arizona, and Southern California, whereas 'dormant' varieties are planted in the Upper Midwest, Canada, and the Northeast. 'Nondormant' varieties can be higher-yielding, but they are susceptible to winter-kill in cold climates and have poorer persistence.

Most alfalfa cultivars contain genetic material from sickle medick (M. falcata), a crop wild relative of alfalfa that naturally hybridizes with M. sativa to produce sand lucerne (M. sativa ssp. varia). This species may bear either the purple flowers of alfalfa or the yellow of sickle medick, and is so called for its ready growth in sandy soil. Traits for insect resistance have also been introduced from M. glomerata and M. prostrata, members of alfalfa's secondary gene pool.

Management
In general, graze or cut for hay when alfalfa is in early bloom. Graze or cut to about a 2-inch height. Successive grazings and cuttings for hay should occur at ¼ bloom stage or after a 5 to 6 week recovery period. Alfalfa can best withstand grazing if rotated frequently or grazed in small strips. The last cutting of alfalfa should be made 3 to 4 weeks before the first killing frost date.

Alfalfa may cause livestock to bloat. Care should be used in managing such grazing to reduce the possibility of this hazard.

Pests and Potential Problems
Alfalfa is susceptible to the spotted or pea aphid, alfalfa weevil, stem nematode, bacterial wilt, snout beetle, and several leaf spots.

Cultivars, Improved, and Selected Materials (and area of origin)
Alfalfa is the oldest crop grown for forage and there are many cultivars available on the open market. More than 440 publicly and privately developed cultivars were approved for certified seed production in the U.S. between 1962 and 1992. For a specific state or region of the U.S., use cultivars that are adapted and have been tested for local performance. Cultivars are readily available from commercial seed vendors.

Control
Please contact your local agricultural extension specialist or county weed specialist to learn what works best in your area and how to use it safely. Always read label and safety instructions for each control method. Trade names and control measures appear in this document only to provide specific information. USDA, NRCS does not guarantee or warranty the products and control methods named, and other products may be equally effective.

Pests
Lucerne is prey to many pests whose activities are often covert and insidious but can also be highly visible and devastating. Damage can occur in the stand at all stages of growth and development from seedling to seeding and plant death may ensue. Damaged plant parts can also be the focus for fungal or bacterial attack and some pests are vectors of plant viruses. The principal pests have been reviewed – insects and mites (Manglitz and Ratcliffe, l988) and nematodes (Leath et al., l988) – but mainly from a North American perspective though the principles and practicalities of combating the pests are universal. In their review of the lucerne crop, Frame et al., (l998) listed 20 major pests.

These can be broadly classed into foliage-, root crown/rot- and seed pod-damaging groups. Apart from direct damage to the foliage by the larvae of alfalfa weevils, cutworms and caterpillars, for example, the foliage growth can be indirectly and severely affected by crown/root pests such as various species of nematodes. Some leaf-eating pests, e.g. caterpillars, may be controlled by natural predators but others require the use of insecticides, e.g. autumn-applied against adult alfalfa weevils or spring-applied against their larvae.

Other pests such as aphids can be controlled to some extent by varying the timing of harvests from the ‘normal’ pattern but this may influence yield (Latheef et al., l988). The stem nematode is a significant pest of lucerne and though there are resistant cultivars, they are not resistant to all nematode biotypes ; rotation with arable crops, which is effective against some pests and diseases, is not totally effective against nematodes because of their long-term viability but is effective against the larvae of the snout beetle. Seed production is affected indirectly by pests which attack foliage and roots but also directly by sap-sucking mirids in the inflorescences or by the larvae of alfalfa seed chalcids feeding on seed pods.

It is necessary to harness the various methods of pest control, either individual, or in combination through integrated pest control (Fleming, l988). These methods include the use of resistant cultivars, cultural control such as manipulation of cutting dates, insecticide use as required and if cost effective, and rotation with arable crops.

Management and Chemical Control
Roundup Ready Alfalfa

- Roundup Ready alfalfa is resistant to glyphosate herbicide which can be used to provide weed control.

- Roundup Ready alfalfa can provide high quality, weed-free forage with excellent crop safety and minimal harvest restrictions.

Importance of Weed Management

- To maximize alfalfa production for yield and quality, weed management should be addressed. The most critical time for weed management in alfalfa is during establishment.

- Yield longevity of an alfalfa stand depends on successful initial establishment of the crop since all subsequent harvests are dependent on initial stand density.

Stand Establishment

- To maximize the benefits of Roundup Ready alfalfa, glyphosate should be applied to seedling alfalfa at the 3 to 5 trifoliate stage when weeds are less than 4 inches tall. If weed problems persist, an additional application of glyphosate can be made up to 5 days prior to harvest.

- An initial glyphosate application is necessary at the 3 to 5 trifoliate stage to remove the small percentage of glyphosate-susceptible alfalfa plants that are present in the new seeding.

Stand Removal

- Roundup Ready alfalfa removal prior to crop rotation is similar to conventional alfalfa varieties. Growth regulator herbicides such as 2,4-D and dicamba are the most common herbicides for removing alfalfa prior to crop rotation in no-till conditions. Deep tillage is also effective for removing established alfalfa stands.

Alfalfa (*Medicago sativa*) is an important perennial forage crop used around the world. Alfalfa is the fourth largest crop, in terms of acreage, grown in the United States behind corn, soybeans, and wheat. Unlike annual cropping systems, alfalfa management differs greatly due to its perennial habit of growth. The alfalfa crop will remain in the field for several growing seasons and will be harvested several times each season. Therefore, with alfalfa, management practices will not only affect the first harvest of the crop, but will also affect subsequent harvests within the life of the alfalfa stand.

Importance of Weed management

Alfalfa forage composition as affected by weeds can have significant impacts on protein content and overall feed quality (Cords 1973). Weed management in alfalfa is critical during stand establishment to ensure successful plant population. Alfalfa seedlings establish slowly and are very sensitive to competition for limited resources. Weed competition during establishment will reduce alfalfa seedling vigor and potentially reduce the alfalfa plant population, which can affect crop yield and quality throughout the life of the stand. In Pennsylvania, Stout et al. (1992) demonstrated that controlling weeds during the establishment year reduced stress on alfalfa, increased seedling weight and leaf numbers, and ultimately increased yields the following year. Leaf number and leaf content in alfalfa hay are direct indicators for digestibility, crude protein, and relative feed value (Kuehn et al. 1999). In addition, successful weed seed production during alfalfa establishment will potentially increase weed seed reserves in the soil, contributing to future infestations.

Once alfalfa is established and is successfully into the forage production period (after the first harvest), well managed alfalfa stands are generally vigorous and aggressive enough to compete well with later emerging weeds. In fact, over 95% of weed control in a healthy established alfalfa crop can be attributed to the alfalfa's competitive nature. Thus, careful weed management during the establishment period of alfalfa is essential for maximum returns from an alfalfa crop over the life of the stand.

What Is roundup ready alfalfa?
The introduction of Roundup Ready alfalfa provides a new option for weed management in alfalfa. Roundup Ready alfalfa incorporates genetic resistance to the herbicide glyphosate (Roundup, Touchdown, Glyphomax, etc.) into the alfalfa plant. Similar to other Roundup Ready crops on the market today such as corn and soybean, a single bacterial gene that modifies 5-enolpruvylshikimate-3-phosphate (EPSP) synthase has been inserted into the alfalfa plant to allow resistance to glyphosate.

EPSP synthase is present in most plants and is an enzyme essential for protein synthesis and normal plant growth. When glyphosate is applied to susceptible plants, glyphosate blocks EPSP synthase preventing the production of essential amino acids and the plant dies. However, in plants that are Roundup Ready, a modified EPSP synthase is unaffected by glyphosate and allows the plant to continue growing. There is little or no crop injury associated with glyphosate application and Roundup
Ready alfalfa.

Where Does Roundup Ready Alfalfa Fit?
Roundup Ready alfalfa is a potential solution for historically weedy fields that are to be planted to alfalfa. Fields with perennial weed problems may also be good candidates. The effectiveness of glyphosate and other herbicides on common alfalfa weeds are described in Table 1. Roundup Ready alfalfa may also help in the establishment of no-till alfalfa stands; however, additional research is still needed on effectively using no-till in Roundup Ready alfalfa.

Table 1. Effectiveness of selected POST herbicides for weed control in seedling and/or established Roundup Ready alfalfa.

Spring Alfalfa Establishment	**Glyphosate**	**Buctril[1]**	**Butyrac**	**Pursuit**	**Raptor**
Foxtail, giant[2]	9+	-	-	9	9
Ragweed, common	9+	9	9	8	8+
Lambsquarters, common	9+	9+	8+	7	9
Velvetleaf	9	8	9	9	9
Pigweed, smooth	9	8	8+	9	9
Crop injury	0	2+	1+	1	1
Late Summer Alfalfa Establishment	**Glyphosate**	**Buctril[1]**	**Butyrac**	**Pursuit**	**Raptor**
Lambsquarters, common	9	9	9	8	8+
Dock, curly	9	N	6	8	8
Chickweed, common	9+	6	6	8+	8+
Shepherds purse	9	9	9	8+	9
Crop injury	0	2+	1+	1	1

Table compares the relative effectiveness of herbicides on individual weeds. Ratings are based on labeled application rates and weed size or growth stage. Results may differ with variation in weed size, temperature, rainfall, soil moisture, soil type, and soil pH. Crop injury rating of 1 or less is rarely significant. Ratings were collected from trials conducted in Pennsylvania or neighboring states.

Weed Control Rating
10 = 95-100%
9 = 85-95%
8 = 75-85%
7 = 75-65%
6 = 65-55%
5 = 55-45%

Crop Tolerance
0 = Excellent
1 = Good
2 = Fair
3 = Poor
[1] Labeled for seedling alfalfa only.
[2] Select and Poast Plus also labeled for grass control in alfalfa.

Although Roundup Ready alfalfa can be an excellent option for weed control in alfalfa, it may not be appropriate for all situations. In particular, alfalfa-grass mixtures and alfalfa seeded with companion or nurse crops are generally not suitable. In addition, fields that tend to have low weed populations may not need the weed control that glyphosate can provide. Finally, fields that are consistently planted to other Roundup Ready crops where glyphosate is routinely used should not be planted to Roundup Ready alfalfa to avoid the selection for glyphosate-resistant weeds.

How do I use Roundup Ready Alfalfa?
Roundup Ready alfalfa management is identical to conventional alfalfa management in all respects except weed control. Roundup Ready alfalfa can be planted in the spring or late summer using standard alfalfa establishment practices. Roundup Ready alfalfa should be seeded at typical rates while the seedbed may be prepared through tillage or if suitable, through no-till.

Once the alfalfa reaches the 3 to 5 trifoliate stage (typically about 4 to 6 weeks after planting) a glyphosate application should be made (Table 2). The importance of this herbicide application is two-fold. First and most importantly, effective weed control should be implemented at this stage so that crop yield losses do not occur from weed competition. Applying glyphosate prior to the 3 to 5 trifoliate stage may be too early for effective weed control since many of the weeds have not emerged by this time (depending on seeding date). If the glyphosate application is made after the 3 to 5 trifoliate stage, some yield loss may occur due to the competitive effects of the weed on the crop; in other words, the damage has already been done.

Table 2. Recommended glyphosate rates and timings for weed control in Roundup Ready alfalfa.

Alfalfa	Application	Rate (lb ai or ae/acre)	Product Rate per acre	Additional Information
Stand Establishment	3 to 5 trifoliate alfalfa stage	0.75 to 1.5	22 to 44 fl. oz Roundup Weathermax 4.5S or 32 to 64 fl. oz 3S formulations	Remove livestock before application and wait a minimum of 5 days after application before grazing, or cutting and feeding forage or hay
Established Stands	After the first cutting, apply up to 5 days prior to harvest	0.75 to 1.5	22 to 44 fl. oz Roundup Weathermax 4.5S or 32 to 64 fl. oz 3S formulations	Same as above

A second reason for glyphosate application at this time is to control the alfalfa “nulls.” Up to 10 percent of the Roundup Ready alfalfa seedlings may not be resistant to glyphosate due to the genetic diversity of alfalfa; these susceptible plants are referred to as “nulls.” If an appropriate glyphosate application is not made early in the life of the alfalfa stand, such as the recommended 3 to 5 trifoliate application, later applications will control the susceptible nulls leaving gaps or holes in the canopy of the alfalfa. However, when glyphosate is applied to seedling alfalfa, the removal of the nulls has no impact on the future production of the stand.

The 3 to 5 trifoliate stage recommendation applies to both spring and late summer seeded alfalfa crops. Late summer seedings may have glyphosate applied in the fall or spring to control weeds.

Some late summer seedings may require an additional herbicide application in the spring if weeds are present. If necessary, the spring application should be made when weeds are actively growing but less than 4 inches tall.

If weed problems persist after the initial application, a second application of glyphosate may be applied up to 5 days prior to first harvest. After the first harvest, and in subsequent years, glyphosate may be applied up to 5 days prior to harvest and when annual weeds are less than 4 inches tall. For perennial weed problems, glyphosate should be applied during early fall. Glyphosate should only be applied when conditions warrant weed control as to reduce the potential development of glyphosate-resistant weeds.

Glyphosate Stewardship

Glyphosate resistance management should always be implemented when using glyphosate-resistant crops, such as Roundup Ready alfalfa. Repeated applications of any herbicide, including glyphosate, may result in herbicide-resistant weeds. Once herbicide-resistant weeds become established within a field, the herbicide becomes ineffective against those weeds that are resistant. Measures to reduce the potential of developing glyphosate-resistant weeds can include crop rotation, herbicide rotation, proper herbicide rate, proper herbicide timing, and alternative weed control methods such as tillage and mowing. Rotation to non-Roundup Ready crops using nonglyphosate herbicides after Roundup Ready crops is also effective in reducing the potential for glyphosate-resistant weeds.

Economic Considerations

Like other Roundup Ready crops, a Technology Use Agreement will be necessary as well as a “Line Item Technology Royalty Fee” in addition to the cost of the seed. When considering the value of this technology, the Royalty fee should be amortized over the life of the stand and the value of glyphosate herbicide should be compared to other competitive products.

How do I Remove Roundup Ready Alfalfa?

When rotating into other crops, some additional consideration should be made for removal of Roundup Ready alfalfa. If properly planned, Roundup Ready alfalfa is no more difficult to remove than conventional alfalfa varieties. Glyphosate, of course, is not effective in the control of Roundup Ready alfalfa; however, glyphosate alone is also not an effective means for control of conventional alfalfa. Alfalfa is often controlled by a combination of tillage and herbicide. Roundup Ready alfalfa should also be removed by similar methods. Currently, the best herbicides for control of alfalfa include 2,4-D, dicamba (Banvel), and clopyralid (Stinger). Greater than 95% control can be achieved with a combination of 2,4-D and dicamba without tillage when used prior to no-till corn.

Specifically, a combination of 1 pt/acre of 2,4-D plus 1 pt/acre of dicamba (0.5 lb ae/acre of each) is the most effective control for Roundup Ready alfalfa; the combination of 2,4-D and dicamba is more reliable and effective than either herbicide alone (Table 3). 2,4-D and dicamba can be applied in the fall or spring prior to corn but should be applied to alfalfa that is actively growing with at least 10 inches of spring growth or 6 inches of post-harvest regrowth. Do not use dicamba prior to planting soybean or other susceptible crops.

Table 3. Roundup Ready alfalfa stand removal prior to no-till corn[1].

Herbicide(s)[2]	Rate	Alfalfa

Table compares the relative effectiveness of herbicides for control of Roundup Ready alfalfa. Ratings are based on labeled application rates and alfalfa size or growth stage. Results may differ with variations in alfalfa size, temperature, and rainfall. Ratings were collected from trials conducted in Pennsylvania and from neighboring states.

Alfalfa Control Rating
10 = 95-100%
9 = 85-95%
8 = 75-85%
7 = 75-65%
6 = 65-55%
5 = 55-45%
[1] Only 2,4-D may be applied prior to soybean planting. Follow label guidelines.
[2] Herbicide should be applied to alfalfa with at least 10 inches of spring growth or after 6 inches of alfalfa regrowth.

2,4-D LV4	1 pt/A	7+
dicamba	1 pt/A	8
2,4-D LV4 + dicamba	1 + 1 pt/A	9
2,4-D LV4 + dicamba	1 + 0.5 pt/A	8+
2,4-D LV4 + dicamba	0.5 + 1 pt/A	8
2,4-D LV4 + dicamba	0.5 + 0.5 pt/A	8
Clopyralid (Stinger)	8 oz/A	9

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Big Sagebrush *Artemisia tridentata* Nutt.
Plant Symbol = ARTR2

Uses
Livestock: The leaves are high in protein but the bitter resinous taste prevents extensive grazing by cattle. Sheep will eat young plants and new growth readily when other forages are dry. They will also make considerable use of the plant in the winter.

Wildlife: Sage grouse are the heaviest users of sagebrush. As much as 70 to 75 percent of their diet is made up of foliage and flower clusters of the plant. Antelope eat substantial amounts of sagebrush throughout the year, and mule deer feed heavily on the plant during late fall, winter, and spring, particularly if other foods are covered with snow. Sharp-tailed grouse, jackrabbits, elk, and many species of small mammals eat sagebrush sparingly during various times of the year. Sagebrush provides nesting cover for sage grouse, and to a lesser extent pheasants and several species of prairie sparrows. It provides loafing and escape cover for sage grouse, chukar, sharp tailed grouse, gray (Hungarian) partridge, pheasants, quail, jackrabbits, and deer.

Status
Please consult the PLANTS Web site and your State Department of Natural Resources for this plant's current status (e.g. threatened or endangered species, state noxious status, and wetland indicator values).

Weediness
This plant may become weedy or invasive in some regions or habitats and may displace desirable vegetation if not properly managed. Please consult with your local NRCS Field

Description
Big sagebrush and its subspecies are tall, rounded, U.S. native shrubs with short branched, woody trunks. The height is normally about 4 feet, but varies from 2 feet in arid conditions to as high as 15 feet on favorable sites. The winter persistent leaves are wedge to fan-shaped and are usually three-lobed at tips. They are strongly aromatic. Buds form about June with flowering and seed formation in the fall.

Adaptation and Distribution
Big sagebrush is drought tolerant but cannot stand excessive sub-moisture. It grows on moderately shallow to deep, well drained, sandy to silt loam soils of neutral to slightly alkaline reaction. Big sagebrush occurs on practically all range except meadows and at high elevations.

Establishment
This has not been a factor to date since its value hasn't been considered great enough. Control has been more important. It is a good seed producer and increases rapidly when soil is disturbed in its natural habitat. Livestock over-grazing can also promote the increase of big sagebrush populations.

A new variation of big sagebrush being recognized by some is Bonneville big sagebrush. This as yet undescribed taxon may represent hybridization between Wyoming and mountain big sagebrush. It is reported to have the general growth form of Wyoming plants but bears the leaves and fluorescing characteristics of the mountain subspecies. It has been reported from the bench areas of Lake Bonneville and other ancient lakes of the Intermountain West in Utah and Nevada. Reports of Bonneville big sagebrush have also come from western Wyoming and western Colorado. Of particular importance is this sagebrush's reported high palatability to wild ungulates and sage grouse.

Subalpine, or spicate big sagebrush, is believed to be a stabilized hybrid between mountain big sagebrush and silver sagebrush (*Artemisia cana* Pursh ssp. *viscidula* [Osterhout] Beetle). Plants are similar to those of mountain big sagebrush except that leaves and floral heads are larger, the floral heads having 10 to 18 flowers per head. Ultraviolet visible coumarins in leaf extracts fluoresce blue in water and blue-cream in alcohol. 2n = 18 or 36.

Parish"s big sagebrush is an uncommon taxon restricted to dry, sandy soils in the hills of southern California. It is nearest in appearance and relationship to basin big sagebrush, but differs from basin in having drooping flowering branches and the achenes are hairy. 2n = 36.

One additional taxon that should be mentioned is Lahontan sagebrush (*Artemisia arbuscula* ssp. *longicaulis* Winward and McArthur). It is thought to be a stable hybrid between low sagebrush (*A. arbuscula*) and Wyoming big sagebrush. It bears the flowers of low sagebrush but has the vegetative characteristics of its big sagebrush parent. This subspecies forms dominant communities in northwestern Nevada and adjacent portions of California and Oregon in shallow or clayey soils above and around the shoreline of the Pleistocene Lake Lahontan.

Distribution
Fossil records and records from early pioneers indicate that sagebrush was widespread and existed in nearly the same general distribution for the past several thousand years as it does in the present day. Densities of sagebrush communities, however, have been reduced historically due to range management practices. Big sagebrush presently covers a vast ecological range from British Columbia to Baja California eastward to the Dakotas. Mahalovich and McArthur (2004) provide distribution as well as seed and plant transfer guidelines for *Artemisia* subgenus *Tridentatae*. For current distribution for each subspecies, please consult the Plant Profile page for this species on the PLANTS Web site.

Habitat
The big sagebrush complex is adapted to a wide range of precipitation zones and soil conditions. Plants are well adapted to the arid plains, valleys, foothills and mountains of the West where annual precipitation ranges from as little as 200 to as much as 750 or more mm (8 to 30 in). It is often found growing in loamy to sandy loam soils, but plants are found on all 12 soil textural classes in five soil orders: Alfisols, Aridisols, Entisols, Inceptisols and Mollisols. Tolerance to alkalinity or acidity varies by subspecies. In general big sagebrush will grow in soils with a pH of 5.9 to 10.0 and with organic matter content of 0.62 to 4.14 percent.

Basin big sagebrush is commonly found at low to mid elevations from 600 to 2,100 m (1,900 to 6,900 ft) in valleys and mountain foothills, occupying sites with deep fertile loamy to sandy soil, 0.9 m (3 ft) or deeper. It is often the dominant shrub species of the plant community, but is also found in association with juniper, piñon pine and rabbitbrush communities. Basin big sagebrush has a deep penetrating root system that allows it to occupy deeper soils in areas receiving little precipitation. Plants are often found growing in valleys, plains, alluvial fans and in seasonal or perennial stream channels. Basin big sagebrush prefers soils which are non-alkaline, non-saline and non-calcareous. The deep root system does not allow plants to grow in soils with a soil depth limiting hardpan or caliche layer. Depending on soil infiltration and water storage capacity, plants will grow in areas receiving less than 200 to more than 400 mm (8 to 16 in) annual precipitation. This subspecies also does not tolerate soils saturated for more than a few weeks in a season.

Management
Historically, sagebrush communities have been poorly managed, mostly in attempts to reduce or eliminate sagebrush stands to increase forage production for livestock. Recently, however, the value of sagebrush to the western rangelands is being recognized, and practices are evolving to better manage healthy and productive sagebrush communities. Contrary to long standing beliefs, studies show that complete sagebrush removal negatively affects biodiversity and has little long term effect on perennial grass production. Indeed, several studies indicate that forage production may actually decline when sagebrush is completely removed or controlled.

Overgrazing of the understory decreases plant biodiversity, especially the forb component of the plant community and increases the density of weeds. Annual weeds, such as cheatgrass (*Bromus tectorum* L.) and medusahead (*Taeniatherum caput-medusae* [L.] Nevski) often out-compete young sagebrush seedlings and create undesirable monocultures. Annual weed infestations also increase the frequency of wildfires which result in eliminating sagebrush stands therefore not allowing stand re-establishment.

Despite the many valuable benefits of sagebrush to rangelands, there may be cases when it is desirable to thin and rejuvenate sagebrush stands. In these instances it is not necessary to remove the entire stand, and control treatments in mosaic patterns are recommended. Several methods exist for partial removal of the shrubby over story.

Herbicide use is an effective means of thinning sagebrush stands. Contact your local agricultural extension specialist or county weed specialist to determine what works best in your area and how to use it safely.

Probably the simplest and most cost effective means of stand reduction is through prescribed burning. If there is sufficient fuel, a burn can completely eliminate a sagebrush community. For this reason niche burning is recommended when possible. In situations where cheatgrass is a dominant part of the understory, burning should take place when ripe cheatgrass seeds are still on the plants and will be consumed in the fire.

Methods of mechanical removal for sagebrush include anchor chaining, pipe harrowing, land imprinting offset disking and brush beating with brush hogs or mowers.

Of these, chaining and land imprinting are the least expensive and do an excellent job of reducing sagebrush stands while still leaving enough plants for diversity and browsing. Brush beating does a good job, but it is expensive. Disking and harrowing also do a good job of shrub removal, but are more expensive and more destructive to under-story plant populations.

Pests and Potential Problems
Perhaps the greatest danger to sagebrush stands comes from fire. Big sagebrush plants have no fire resistance and many acres are destroyed annually because of increased fire frequency resulting from infestations of exotic annual weeds such as cheatgrass and medusahead.

Another minor cause of sagebrush mortality is winter injury. This occurs when temperatures drop quickly below freezing before plants have entered dormancy, or when a warm spell promotes winter growth followed by a return to typical winter temperatures. Extended periods of winter and summer drought (normally more than 2 years) can also cause dehydration and death.

Big sagebrush is occasionally susceptible to limited outbreaks of the sagebrush defoliator moth, or webworm, (*Aroga websteri*). Although the moths can cause extensive damage, they too are subject to insect predators, and it is rare that entire stands will be lost.

Additionally, there are a number of other microbial and fungal pathogens known to attack big sagebrush. Although these may inflict serious damage locally, they have not been viewed as a great threat to sagebrush populations.

Seed and Plant Production
The vast majority of big sagebrush seed used in revegetation is wildland collected material. Seed collection occurs in late fall to early winter (early October through the end of December) depending on the subspecies. Collections are commonly made by hand stripping, beating or clipping seed heads into containers or by using a reel type harvester. Seed can be cleaned with a hammermill, debearder, air-screen or gravity table with varying results. Most sagebrush seed lots used for rangeland seeding are only cleaned to a purity of 15 to 20 percent due to the small nature of the seeds (achenes). This practice requires less time for cleaning and also allows for easier seed flow and metering in seeding equipment. Pure seed yields approximately 1.7 to 2.5 million seeds per pound. The NRCS Plant Materials Center in Bridger, MT reported four hours collecting time and 5.5 hours cleaning yielded 200g (0.45 lb) cleaned material, or 21g (0.04 lb) per hour.

Sagebrush seed that has been dried to a minimum of 9 percent moisture content will remain viable for many years when stored under cool, dry conditions. Welch et al (1996) reported seed viabilities above 90% for seed stored at 10 ºC (50 ºF) and relative humidity (RH) of 20 percent after nine years of storage. Seed stored at higher RH levels are susceptible to germination or damage by insects or microorganisms.

Control
Control is accomplished by chemical sprays, fire, railing, chaining, and beating. Good range management of deep-rooted perennial grasses is a control measure.

Please contact your local agricultural extension specialist or county weed specialist to learn what works best in your area and how to use it safely. Always read label and safety instructions for each control method. Trade names and control measures appear in this document only to provide specific information. USDA, NRCS does not guarantee or warranty the products and control methods named, and other products may be equally effective.

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USE PESTICIDES WISELY: ALWAYS READ THE ENTIRE PESTICIDE LABEL CAREFULLY, FOLLOW ALL MIXING AND APPLICATION INSTRUCTIONS AND WEAR ALL RECOMMENDED PERSONAL PROTECTIVE GEAR AND CLOTHING. CONTACT YOUR STATE DEPARTMENT OF AGRICULTURE FOR ANY ADDITIONAL PESTICIDE USE REQUIREMENTS, RESTRICTIONS OR RECOMMENDATIONS.

NOTICE: MENTION OF PESTICIDE PRODUCTS IN THIS COURSE DOES NOT CONSTITUTE ENDORSEMENT OF ANY MATERIAL.

Giant Hogweed *Heracleum mantegazzianum Sommier & Levier* HEMA17

Habit
Biennial or perennial herb with a deep (40-65 cm or 16-26 in), branching tap root; blooms once then dies (monocarpic); some perennials have survived after flowering.

Reproduction
By seed; cut stems may re-sprout; self-compatible, outcrossing, protandrous hermaphrodite.
Leaves: Alternate; up to 3 m (10 ft) long, three-parted and pinnate; pubescent beneath; petiole base enlarged, surrounding the stem; upper leaves become gradually smaller.
Stems: Often purple-mottled, 2-5 m (7-16 ft) tall, up to 10 cm (4 in) in diameter; hollow and ridged.
Flowers: Compound umbel up to 1.5 m (5 ft) in diameter with 50 to 150 rays; white; most plants flower in third or fourth year; June-August; pollinated by a variety of insects, mostly bees and flies; self-pollination may occur between different umbels.
Fruits/Seeds: Fruit elliptic, ridged, and winged, 8-15 mm in length on elongate stalks; splits in half, each half with one seed; shed Aug.-Oct.; over 100,000 seeds per plant possible; water, wind, or human dispersed, mostly within 10 m (33 ft) of mother plant; germination appears to require moisture and cold stratification and will occur in light or dark; viability ranges between 2-15 years.

Habitat
Native to southwestern Asia; introduced as an ornamental; waste places, roadsides, disturbed woodlands, and streambanks; may invade a range of habitats, but possible preference for open, mesic, and seasonally cold environments.

Comments: Sap has secondary compounds (furanocoumarins) that may cause blistering and rashes on humans, with sun exposure; some of the same substances inhibit insect herbivory by generalists but specialist insect herbivory is common; cattle, sheep, goat, pig, mollusk, and snail grazing are common.

Similar Native Species: Cow-parsnip (H. lanatum); flower usually has only 15-30 rays and stem reaches only 3 m (10 ft).

Weed Management

Glyphosate

Rate 1.5 lb ae/A
Time Apply in spring during the bolting stage.
Remarks Avoid physical contact with the plant.
Caution Controls grasses as well as other vegetation in treated area.
Site of action Group 9: inhibits EPSP synthase
Chemical family None generally accepted

Glyphosate (Roundup Pro Concentrate)

Rate Inject 5 ml of a 5% v/v solution into each leaf cane.
Time Inject with a hand-held device, into one leaf cane per plant 12 inches above root crown.
Remarks Mark each plant when injecting it, to avoid re-treating the same plant.
Caution Non-crop use only. Total of all treatments must not exceed 8.5 quarts/A of Roundup Pro Concentrate or 1,600 plants/A.
Site of action Group 9: inhibits EPSP synthase
Chemical family None generally accepted

Imazapic (Plateau)

Rate 0.188 lb ai/A
Time Apply in spring during the bolting stage.
Remarks Avoid physically contacting plant when applying. Add an appropriate adjuvant to spray mix.
Caution Consult label on where Plateau can be used. Before using, note crop rotation restrictions.
Site of action Group 2: acetolactate synthase (ALS) inhibitor
Chemical family Imidazolinone

USE PESTICIDES WISELY: ALWAYS READ THE ENTIRE PESTICIDE LABEL CAREFULLY, FOLLOW ALL MIXING AND APPLICATION INSTRUCTIONS AND WEAR ALL RECOMMENDED PERSONAL PROTECTIVE GEAR AND CLOTHING. CONTACT YOUR STATE DEPARTMENT OF AGRICULTURE FOR ANY ADDITIONAL PESTICIDE USE REQUIREMENTS, RESTRICTIONS OR RECOMMENDATIONS.

NOTICE: MENTION OF PESTICIDE PRODUCTS IN THIS COURSE DOES NOT CONSTITUTE ENDORSEMENT OF ANY MATERIAL.

Hairy Willowherb *Epilobium hirsutum* Willowherb Family

Identification Tips

- ✓ Semi-aquatic perennial herb covered with soft hairs
- ✓ Grows up to 6 feet tall
- ✓ Stems are erect and branched
- ✓ Showy rose or purple colored flowers with four notched petals
- ✓ Leaves are opposite, lance-shaped with toothed edges and attach directly on the stem
- ✓ Long, narrow seed pods that split open to release numerous seeds with long white hairs

Biology

- ✓ Spreads primarily vegetatively by thick rhizomes
- ✓ Also spreads by windblown seeds
- ✓ Flowers from July through August
- ✓ Rapid growth and spread in early autumn
- ✓ Has the ability to adapt to submerged areas through the development of aerenchymal tissues

Impacts

- ✓ Aggressive growth pushes out native plant species
- ✓ Forms dense stands that impedes water flow in waterways and wetlands
- ✓ Easily spreads to undisturbed areas

Distribution

- ✓ Found in low pastures, ditches, wetlands, stream banks, fields and meadows
- ✓ Grows in moist to wet soils; often found growing in the same areas as the weed purple loosestrife
- ✓ Prefers sunlight and open spaces without dense tree cover
- ✓ Rhizomes can grow submerged in water or in water-saturated mud, but will also spread to undisturbed meadows

Control Methods
Most control methods need to be applied over several years to be successful. Due to the highly invasive nature of hairy willowherb, off-site composting is not recommended as a disposal option.

Prevention
Beware of varieties sold as ornamentals. If recreating in areas with hairy willowherb, check boat hulls, motors and other equipment for plant fragments that can be transported to new waterways.

Manual: Small infestations can be dug up, bagged and disposed of in the regular trash, taking care remove as much of the rhizomes and root fragments as possible. Mature flowering stems can be cut at base in late summer or early fall to prevent seed production. Brush off boots and clothes before leaving the infested area. Site must be checked for regrowth from missed root fragments and seed dispersal.

Mechanical: Cutting or mowing by itself is not an effective control option for hairy willowherb. Shoots and adventitious roots will develop. Black plastic covering is an interim option for dense seedling infestations. It does not kill mature plants, but it does slow down growth and seed production.

Chemical: Chemical control options may differ for private, commercial and government agency users. Follow all label directions and local regulations regarding herbicide use in sensitive areas. Certain herbicides cannot be used in aquatic areas or their buffers. If herbicides are used, make sure that their label specifies your type of site. All aquatic herbicides are restricted-use herbicides. Purchase and application of these herbicides can only be done by licensed aquatic herbicide applicators.
Permits may be required before applying aquatic herbicides.

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Herb Robert *Geranium robertianum* Geranium Family

Identification Tips
Annual or biennial

- ✓ Young plants are low-growing rosettes; mature plants are taller, up to 10 inches with branched stems
- ✓ Stems often dark red and covered with white glandular hairs that give it a slightly sticky or oily feel
- ✓ Flowers range in color from bright pink to white
- ✓ Deeply dissected green leaves
- ✓ In the fall, overall foliage turns a bright red, especially in sunny areas
- ✓ Distinct odor when plant is pulled or crushed

Biology

- ✓ Spreads entirely by seeds which can eject 15 to 20 feet from plant
- ✓ Seeds germinate from early spring to late fall and remain viable in the soil for 6 years or more
- ✓ Roots are shallow and fibrous
- ✓ Flowers from mid-spring to late fall
- ✓ Fruits are long, tapering and beak-like

Impacts

- ✓ Out-competes native plant species, especially in the understory of forests
- ✓ Seeds are sticky, adhering to wildlife, people and pets which facilitates a wider range of infestation
- ✓ Rosettes overwinter, giving it a head start in the spring

Distribution

- ✓ Found in ravines, greenbelts, parks, forests and farmlands as well as residential settings such as flower gardens, rockeries and ornamental borders
- ✓ Thrives in deep shade, but also does well in partly sunny areas
- ✓ Likes moist soil, but is also found on dry rocky outcrops and along roadsides

Control Methods

For best results, control methods should be used throughout several growing seasons; success in controlling this weed requires the prevention of seeds, competition from more desirable vegetation and vigilance in removing new growth. Gloves are recommended when handling large amounts of this plant as its sticky oils may cause a slight skin irritation.

Control small populations by hand-pulling individuals. Plants are rooted shallowly and will come up easily, especially if the soil is wet. However, due to a brittle root system, it is important to grasp firmly at the base to remove the entire plant. Mechanical equipment, such as weed whackers, also can be used to prevent seed set of patches of this annual. Cut back in early summer. However, follow-up measures will be necessary to control resulting individuals from the existing seed bank.

Prevention: Remove plants before they produce flowers and seeds. Don't dispose in home compost piles; herb Robert seeds can survive and spread from backyard composting. Plant competitive herbaceous species such as woodland strawberry (*Fragaria vesca*) that naturally form a dense mat.

Manual: Herb Robert has weak roots and pulls up easily. Since its seeds have a tendency to spread far and wide, you may find it growing among other invasives such as ivy, blackberry or desirable plants such as bleeding heart, making the task of hand pulling a bit more difficult. Smothering may be an effective means of control if herb Robert forms a uniform stand or exists as clumps in the landscape. Cover with overlapping sections of cardboard and 3-4" of mulch and reapply mulch on a yearly basis. Monitor for resprouts for at least three years.

Mechanical: String trimmers can be effective if used before plants set seed. However, herb Robert does sprawl over and among other plants so care must be given not to cut down non-targeted vegetation.

Chemical: Systemic (translocated) herbicides can be effective on herb Robert, especially if combined with monitoring for surviving plants. Chemical control can be quite effective if herb Robert has already established a monoculture on a site. Glyphosate (Roundup™) is most commonly used. However, herb Robert often occurs initially as part of a mosaic alongside desirable native species. In these situations, alternative control methods that have the ability to target individual plants can more successfully meet all goals of a project.

Choose a formulation that is appropriate for the site: either aquatic or terrestrial. Follow the label exactly as written and only use at the rate that is prescribed on the label. Herbicides can be painted or brushed on leaves to avoid drift onto desirable plants.

Products containing glyphosate are effective when applied to young plants. However, glyphosate is "non-selective" and will injure any foliage that it comes in contact with including grass. Selective broadleaf herbicides with the active ingredients triclopyr and 2,4-D work well for lawn areas as they won't harm most grasses. All these herbicides are absorbed by foliage and moved throughout the plant to kill the roots and should be applied to actively growing, pre-flowering plants to be most effective. Any questions, please contact your Noxious Weed Control Program.

Japanese Stilt Grass
Microstegium vimineum (Trin.) A. Camus; Andropogon vimineus Trin.; Eulalia viminea (Trin.) Kuntze MIVI

Habit: Reclining, loosely branching annual to 1 m (3 ft).
Reproduction: By seed; may root at lower nodes.
Leaves: Mid-vein of leaf blade offset from center; a line of silvery hairs runs down the mid-vein on upper surface; lanceolate, tapering at both ends, 5-10 mm wide, 3-8 cm long; pale green; leaf sheath collars with ciliate hairs.
Stems: Reclining and branching; nodes glabrous and slightly swollen.
Flowers: Late summer/early fall; terminal spike-like, branching inflorescence up to 7 cm long with paired, hairy spikelets; in one variety, one spikelet is awned; another variety both are awnless; may have both cleistogamous and chasmogamous flowers; chasmogamous flowers associated with populations in high light and under water stress; shade populations primarily cleistogamous; potentially highly selfed; flowering plants tend to be larger than non-flowering plants.
Fruits/Seeds: Ellipsoid grain 2.8-3.0 mm long; abundant seed production may occur infrequently; seed bank of at least 3 years; seeds mature and are dispersed in late fall when they appear to be dormant; cold stratification may be required for germination; water and animal dispersed.
Habitat: Native to tropical Asia; introduced into the U.S. in 1919; shade tolerant; preference for shady areas (closed canopy forests, especially riparian areas) but found in high light areas (roadsides, ditches, forest borders, and fields); possible preference for bare ground, disturbed and acidic soil.

Comments: C^4 photosynthesis; may acquire more light energy using sun flecks; has a lower capacity to photosynthesize in high light; forms a thick thatch of litter, which may prevent establishment of natives and itself; may alter soil conditions to its benefit by increasing pH, nitrification, and nitrate; association with non-native earthworms possibly due to increased litter decomposition or an agricultural connection.

Similar Native Species: Leersia virginica; has hairy nodes, is a perennial, and flowers.

Spread Prevention
Since mowing, road maintenance, and timber harvesting equipment can rapidly spread stiltgrass, it is imperative that equipment is inspected and cleaned on a regular basis. When possible, mow non-infested areas prior to mowing areas with known stiltgrass populations, and require loggers and other contractors to sanitize equipment prior to moving on to your property. Care should be taken to prevent movement of any above-ground plant parts. Debris from mowing and road maintenance equipment should be disposed of properly.

Since stiltgrass can be spread by foot traffic, horses, and recreational equipment, boot and equipment cleaning can help to limit the spread of seed into non-infested areas. Place high priority in controlling stiltgrass along trails, especially those leading to non-infested areas. Consider rerouting trails that pass through infested areas.

Gravel, topsoil, seed, and mulches are another way that stiltgrass can be inadvertently moved from one place to another. When possible, purchase these products from certified, weed-free sources or at minimum, check with local suppliers to be sure that products do not come from locations infested with stiltgrass or other non-native invasive plants.

Control Methods
Although many control techniques have been attempted with varying levels of success, there are few cost-effective control methods that have minimal impact on native plant populations. Most control methods will need to be repeated for at least a few growing seasons, since control is rarely 100% effective and the seed of stiltgrass may remain viable in the soil for up to 5 years.

Mechanical Control
Hand-pulling can be an effective method of controlling isolated, small populations of stiltgrass; however, it is rarely practical once stiltgrass becomes well-established. Hand-pulling is most effective late in the growing season before seeds mature. Pulling earlier in the growing season can be futile, since seeds in the soil can continue to germinate well into the growing season. Pulled plants should be bagged and removed from the site to prevent seeds from maturing after they are pulled.

Mowing is another control mechanism that has been successfully utilized to manage stiltgrass, but its application is limited to roadsides, open areas, and trail systems that will accommodate mowing equipment. A string-type trimmer or weed eater can be utilized to mow sites that are not accessible by larger equipment.

To be effective, mowing must take place late in the growing season just prior to the establishment of mature seed heads. Mowing of accessible areas is more effective when combined with other control methods in adjacent, infested areas to minimize re-colonization from neighboring populations.

Biological Control
To date, no biological control methods have been effectively used to control Japanese stiltgrass; however, in 2009 a leaf blight fungal disease (*Bipolaris sp*.) was found on stiltgrass populations in West Virginia. It is currently being evaluated for use as a biological control agent.

Chemical Control
Non-selective foliar herbicides such as Roundup, Accord, and other glyphosate-based products can be applied to the foliage of stiltgrass at any time during the active growing season (Table 1); however, since these products have no residual effect, control is most effective when applied in late summer just prior to seed head development to ensure contact with individuals that germinate later in the growing season. Since non-selective herbicides will kill most plants that are contacted, these treatments should be limited to monocultures of stiltgrass or small, isolated populations of stiltgrass that are not growing in close proximity.

Table 2. Herbicides recommended for pre-emergent treatment of Japanese stiltgrass.

Herbicide	Example Brand Names	Comments
Pendimethalin	Pendulum AquaCap	4.2 qts/acre; apply 2–3 weeks prior to germination; will not affect plants that have germinated
Imazapic	Plateau	4–6 oz/acre; treat when plants are less than 4 inches tall; both pre- and post-emergence control
Sulfometuron	Oust XP	1 1/3–3 oz/acre; pre- and post-emergence activity

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Mint *Mentha*

The genus has a subcosmopolitan distribution across Europe, Africa, Asia, Australia, and North America. Mints are aromatic, almost exclusively perennial, rarely annual, herbs. They have wide-spreading underground and overground stolons and erect, square, branched stems. The leaves are arranged in opposite pairs, from oblong to lanceolate, often downy, and with a serrated margin. Leaf colors range from dark green and gray-green to purple, blue, and sometimes pale yellow. The flowers are white to purple and produced in false whorls called verticillasters. The corolla is two-lipped with four subequal lobes, the upper lobe usually the largest. The fruit is a nutlet, containing one to four seeds.

While the species that make up the Mentha genus are widely distributed and can be found in many environments, most grow best in wet environments and moist soils. Mints will grow 10–120 cm tall and can spread over an indeterminate area. Due to their tendency to spread unchecked, some mints are considered invasive

Species
The list below includes all of the taxa recognized as species in recent works on Mentha. No author has recognized all of them. As with all biological classifications of plants, this list can go out of date at a moment's notice. Common names are also given for species that have them. Synonyms, along with cultivars and varieties, are given in articles on the species.

- Mentha aquatica – water mint, marsh mint
- Mentha arvensis – corn mint, wild mint, Japanese peppermint, field mint, banana mint
- Mentha asiatica – Asian mint
- Mentha australis – Australian mint
- Mentha canadensis – American wild mint
- Mentha cervina – Hart's pennyroyal
- Mentha citrata – bergamot mint, orange mint
- Mentha crispata – wrinkled-leaf mint
- Mentha dahurica – Dahurian thyme
- Mentha diemenica – slender mint
- Mentha laxiflora – forest mint
- Mentha longifolia (syn. Mentha sylvestris) – horse mint
- Mentha piperita – peppermint
- Mentha pulegium – pennyroyal
- Mentha requienii – Corsican mint
- Mentha sachalinensis – garden mint
- Mentha satureioides – native pennyroyal
- Mentha spicata (syn. M. viridis, M. cordifolia) – spearmint, curly mint (a cultivar of spearmint)

- Mentha suaveolens – apple mint, pineapple mint (a variegated cultivar of apple mint)
- Mentha vagans – gray mint
  Taxonomy

Mentha is a member of the tribe Mentheae in the subfamily Nepetoideae. The tribe contains about 65 genera, and relationships within it remain obscure. Authors have disagreed on the circumscription of Mentha. Some authors have excluded M. cervina from the genus. M. cunninghamii has also been excluded by some authors, even in some recent treatments of the genus. In 2004, a molecular phylogenetic study indicated both of these species should be included in Mentha.

Selected hybrids
The mint genus has a large grouping of recognized hybrids. Synonyms, along with cultivars and varieties where available, are included within the specific species.

- Mentha × dalmatica (M. arvensis × M. longifolia)
- Mentha × dumetorum (M. aquatica × M. longifolia)
- Mentha × gracilis (M. arvensis × M. spicata) – ginger mint
- Mentha × maximilianea (M. aquatica × M. suaveolens)
- Mentha × piperita (M. aquatica × M. spicata) – peppermint, chocolate mint
- Mentha × rotundifolia (M. longifolia × M. suaveolens) – false apple mint
- Mentha × smithiana (M. aquatica × M. arvensis × M. spicata) – red raripila mint
- Mentha × verticillata (M. aquatica × M. arvensis)
- Mentha × villosa (M. spicata × M. suaveolens also called M. nemorosa) – large apple mint, foxtail mint, hairy mint, woolly mint, Cuban mint, mojito mint, and yerba buena in Cuba
- Mentha × villosonervata (M. longifolia × M. spicata) – sharp-toothed mint
  Cultivation

All mints thrive near pools of water, lakes, rivers, and cool moist spots in partial shade. In general, mints tolerate a wide range of conditions, and can also be grown in full sun. Mint grows all year round.

They are fast-growing, extending their reach along surfaces through a network of runners. Due to their speedy growth, one plant of each desired mint, along with a little care, will provide more than enough mint for home use. Some mint species are more invasive than others. Even with the less invasive mints, care should be taken when mixing any mint with any other plants, lest the mint take over. To control mints in an open environment, they should be planted in deep, bottomless containers sunk in the ground, or planted above ground in tubs and barrels.

Some mints can be propagated by seed, but growth from seed can be an unreliable method for raising mint for two reasons: mint seeds are highly variable - one might not end up with what one presupposed was planted, and some mint varieties are sterile. It is more effective to take and plant cuttings from the runners of healthy mints.

The most common and popular mints for cultivation are peppermint (Mentha × piperita), spearmint (Mentha spicata), and (more recently) apple mint (Mentha suaveolens).

Mints are supposed to make good companion plants, repelling pesky insects and attracting beneficial ones. They are susceptible to whitefly and aphids.

Harvesting of mint leaves can be done at any time. Fresh leaves should be used immediately or stored up to a few days in plastic bags in a refrigerator. Optionally, leaves can be frozen in ice cube trays. Dried mint leaves should be stored in an airtight container placed in a cool, dark, dry area.

Spearmint *Mentha spicata L.*
Peppermint *Mentha × piperita L. (pro sp.) aquatica × spicata*

Mentha spicata L

Introduction: Spearmint and peppermint share very similar biological and ecological attributes. For this reason, discussions of their descriptions, ecological impacts, biological traits, legal listings, distributions, and control methods are combined.

Synonyms for Mentha spicata: Mentha longifolia auct. non (L.) Huds., M. longifolia var. mollissima (Borkh.) Rouy, M. longifolia var. undulata (Willd.) Fiori, M. pudina Buch.-Ham. ex Benth., M. spicata var. longifolia L., M. spicata L. var. spicata, M. spicata var. viridis L., M. sylvestris L., M. viridis L.
Other common names: bush mint

Synonyms for Mentha ×piperita: Mentha aquatica var. crispa (L.) Benth., M. crispa L., M. dumetorum Schultes

Family: Lamiaceae

Description
Spearmint is a rhizomatous, perennial herb that grows from 30 to 100 cm tall. The entire plant has a strong, pleasant, minty smell. Stems are erect, branched, glabrous, grooved, and four-angled. Leaves are ovate to lanceolate, 2 to 7 cm long, 5 to 25 mm wide, pointed at the tips, and rounded at the bases with toothed margins. They are mostly glabrous, although they may be hairy on the main veins of the lower surfaces. They are sessile or have petioles less than 3 mm long. Inflorescences are dense, terminal, 3 to 12 cm long, and 5 to 10 mm wide.

Flowers appear whorled but arise from the axils of opposite, subtending bracts. Petals are pale lavender to white, fused, tubular, four-lobed, and 2 to 4 mm long. Calyxes are 1.5 to 2 mm long and glabrous but often glandular with hairy, toothed margins. Bracts are linear to lanceolate and shorter than or equal to the flower length. Flowers produce four nutlets each. Nutlets are ovoid and dark brown (DiTomaso and Healy 2007, eFloras 2008, Klinkenberg 2010).

Peppermint, a sterile hybrid of spearmint and water mint (Mentha aquatica), is similar to spearmint, but it often has red- or purple-tinted stems. Leaves have short petioles. Flowers are pale pink or purple (Stace et al. 2005, Abbaszadeh et al. 2009).

Similar species: Both spearmint and peppermint can be confused with the native field mint (Mentha arvensis). Field mint grows in all three ecogeographic regions of Alaska south of the Brooks Range (Hultén 1968, UAM 2010). It can be distinguished from spearmint and peppermint by the presence of flowers that are borne in widely separated clusters in the leaf axils and stems that are terminated by leaves. Unlike spearmint and peppermint, field mint often has hairy stems and leaves (Hultén 1968). Other Lamiaceae species in Alaska lack a minty smell.

Ecological Impact

Impact on community composition, structure, and interactions: Spearmint has been documented growing in a natural, marshy area in Tennessee, but no ecological impacts were documented (Drake et al. 2002). Spearmint and peppermint were found growing around springs in southwestern Wisconsin, but, again, no ecological impacts were documented (Tenorio and Drezner 2006). These Mentha species establish mainly in moist to wet, disturbed areas (DiTomaso and Healy 2007, Klinkenberg 2010). They may increase the density of vegetation and limit the sizes of native plant populations in these habitats by extensive spread from rhizomes (DiTomaso and Healy 2007, Abbaszadeh et al. 2009), competition for nutrients, and the allelopathic action of their essential oils (Azirak and Karaman 2008). We are not aware of perceivable impacts to existing vegetation structure in Alaska. Spearmint and peppermint generally repel pest insects and attract beneficial insects. These species are susceptible to herbivory from whiteflies and aphids (Abbaszadeh et al. 2009). They are pollinated by bees and other insects; therefore, the presence of spearmint and peppermint may alter native plant-pollinator interactions. The impacts of these Mentha species on associated trophic levels are largely undocumented.

Impact on ecosystem processes: Spearmint and peppermint are likely to reduce the nutrients available to native plant species, but only in moist to wet, disturbed sites (DiTomaso and Healy 2007).

Biology and Invasive Potential

Reproductive potential: Spearmint and peppermint both reproduce vegetatively from wide-spreading rhizomes (DiTomaso and Healy 2007, Abbaszadeh et al. 2009). The shoot yield of both species ranges from approximately 1,800 to 2,100 kg per hectare in Iran. Peppermint is sterile and produces no viable seeds (Abbaszadeh et al. 2009, Ling 2010). Neither the seed production nor the amount of time seeds remain viable has been quantified for spearmint.

Role of disturbance in establishment: Spearmint escapes cultivation and grows in disturbed vegetation (DiTomaso and Healy 2007, Klinkenberg 2010, Western Australian Herbarium 2010). It is not likely to spread to natural areas (Drake et al. 2002).

Potential for long-distance dispersal: The long-distance dispersal of peppermint is limited by its exclusively vegetative reproduction (Abbaszadeh et al. 2009). The fruits of spearmint, which consist of four nutlets enclosed by the calyx, can be dispersed by water and can cling to animal fur (DiTomaso and Healy 2007).

Potential to be spread by human activity: Spearmint and peppermint are commonly planted in gardens throughout the U.S. and escape from cultivation into disturbed, moist areas (Hultén 1968, DiTomaso and Healy 2007). Rhizome fragments and seeds can be spread on agricultural and construction equipment (DiTomaso and Healy 2007).

Germination requirements: Spearmint seeds usually germinate quickly (Plants for a Future 2010).

Growth requirements: Spearmint and peppermint grow best in wet or moist, slightly acidic soils (Abbaszadeh et al. 2009, Plants for a Future 2010). They tolerate light conditions ranging from full sunlight to partial shade (Abbaszadeh et al. 2009).

Congeneric weeds: Pennyroyal (Mentha pulegium) and apple mint (M. suaveolens) are considered non-native weeds in California (DiTomaso and Healy 2007).

Distribution and Abundance
Spearmint and peppermint are cultivated commercially for use in flavorings and medicines. They are also cultivated in gardens throughout much of the world as food herbs and medicinal herbs (Lawrence 2006, eFloras 2008, Abbaszadeh 2009). In North America, spearmint grows in moist to wet disturbed areas, aquatic sites, stream banks, swamps, ditches, and meadows (Klinkenberg 2010, Ling 2010).

Native and current distribution: Spearmint is native to the Balkan Peninsula and Turkey, and it has been naturalized throughout much of Europe, the Mediterranean region, and Southwest Asia (Kokkini and Vokou 1989, eFloras 2008). It has been introduced to North America, Japan, Australia, and New Zealand (Mito and Uesugi 2004, GBIF New Zealand 2010, USDA 2010, Western Australian Herbarium 2010). Spearmint grows in all states of the U.S. except North Dakota, and it is present throughout much of Canada. Peppermint grows in 44 states of the U.S. (USDA 2010). Neither spearmint nor peppermint has been documented from arctic regions. Spearmint has been documented from the Pacific Maritime and Interior-Boreal ecogeographic regions of Alaska (Hultén 1968, UAM 2010). Peppermint has escaped from cultivation in Alaska, but no specific locations are known (Hultén 1968).

Management
The vegetative spread of spearmint and peppermint in gardens can be controlled by planting these species in plastic containers sunk into the ground (Abbaszadeh et al. 2009). Small infestations and individual plants can be removed manually as long as all rhizomes are dug out (DiTomaso and Healy 2007). Control efforts may need to be repeated to remove plants that regenerate from rhizome fragments.

MINT—Annual and Perennial Broadleaf Weeds
Bentazon (Basagran, Rezult B)

Rate 1 to 2 lb ai/A
Time Apply postemergence to actively growing weeds.
Remarks Rate depends on target weed. Canada thistle should be at least 8 inches tall, western goldenrod less than 8 inches, salsify 4 to 8 inches, and common groundsel less than 3 inches tall at treatment. Make a second application 7 to 10 days later. Bentazon acts on contact, so thorough coverage is important. Use at least 20 gal/A water and at least 40 psi by ground. For aerial application, use at least 5 gal/A water and at least 40 psi. Add up to 1 quart/A of oil concentrate for ground application and 1 pint/A for aerial application. Unsatisfactory results can be expected if daytime temperatures do not reach at least 70°F in the week after application. Good soil moisture is essential for activity on weeds. May be tank mixed with bromoxynil, terbacil, or clopyralid to broaden broadleaf weed control spectrum.
Caution Some mint leaves may burn under certain conditions. Do not apply during unseasonably cold weather or drought. Rain or overhead irrigation within 8 hours may nullify effectiveness of bentazon. Do not exceed 4 lb ai/A in one season. Do not mix with any other pesticide or with fertilizer.
Site of action Group 6: photosystem II inhibitor
Chemical family Benzothiadiazole

Clopyralid (several trade names)

Rate Fall treatment: for annual weeds use 0.19 lb ae/A (0.5 pint/A product); for perennial weeds use 0.25 lb ae/A (0.66 pint/A product); for hard-to-kill perennial weeds use 0.375 lb ae/A (1 pint/A product). Spring treatment: annual weeds use 0.124 lb ae/A (0.33 pint/A product); perennial weeds use 0.19 lb ae/A (0.5 pint/A product); fall plus spring treatment, maximum use 0.66 pint/A product in fall plus 0.33 pint/A product in spring.

Time Treat small, actively growing annual weeds. For Canada thistle, apply after most basal leaves emerge but before bud stage. Fall application on winter annuals and perennials often is more effective than spring application. For difficult-to-control perennials such as Canada thistle and dandelion, a follow-up application in spring may be needed. Applying after the first fall frost usually results in reduced control.
Remarks A nonionic surfactant of at least 80% ai may be added at 1 pint/100 gal spray solution. Do not apply within 45 days of harvest. Clopyralid can cause stunting of mint growth and application to dormant mint or mint under 8 inches tall allows more time for mint to fully recover. Most weeds in the family Compositae or Asteraceae, such as mayweed (dog fennel), groundsel, dandelion, and salsify, and in the legume family, such as vetch, alfalfa and clover, are susceptible to clopyralid. Will not control broadleaf weeds such as mustards, henbit, chickweed, kochia, lambsquarters, pigweed, Russian thistle, and bindweed.
Caution Use treated mint for oil distillation only. Do not feed spent mint hay to livestock. Consult label for crop rotation restrictions. Mint straw, hay, or spent hay from treated areas cannot be used for composting or mulching on ground where susceptible crops may grow the next season.
Site of action Group 4: synthetic auxin
Chemical family Pyridine

Glyphosate (many trade names)
Rate 1% to 2% solution
Time Apply to actively growing weeds.
Remarks Not all glyphosate formulations have mint on the label. Application rate and timing depend on target weeds. Apply as a spot treatment only, to no more than 10% of any acre. Can reapply in the same area at 30-day intervals.
Caution Any emerged crop sprayed will be killed. Avoid any drift outside spayed area, or those plants could be killed or injured. Allow at least 7 days between application and harvest.
Site of action Group 9: inhibits EPSP synthase
Chemical family None generally accepted.

Glyphosate (many trade names)
Rate 33% solution (1 gal Roundup Ultra in 2 gal water) in rope or sponge wick applicators or a 33% to 100% glyphosate solution in porous-plastic applicators
Time Apply to actively growing weeds that are at least 6 inches taller than the mint.
Remarks Not all glyphosate formulations have this use on the label. Wiper applicator contact point with weed foliage should be at least 2 inches above crop. Weeds should be at least 6 inches taller than crop. Results improve by making two applications in opposite directions. Operate at no more than 5 mph. Do not apply to wet weeds.
Caution Contact with herbicide solution, whether by dripping from the applicator or inadvertently wiping the mint, will damage or kill the mint plants contacted. Allow at least 7 days between application and harvest. Sequential application may be made to the same area at 30-day intervals.
Site of action Group 9: inhibits EPSP synthase
Chemical family None generally accepted

MCPB (Thistrol Herbicide)
Rate Use 0.25 to 0.5 lb ae/A (1 to 2 pint/A product).
Time For field bindweed suppression a single spring application works best. Field bindweed control improves as runners begin to exceed 6 to 8 inches. Apply in fall for susceptible winter annuals and in spring for summer annuals when weeds are small and actively growing.
Remarks Do not apply within 40 days of harvest. Many broadleaf weed species will not be controlled at low rates labeled for use in mint.
Caution Mint may be discolored or twisted following MCPB application. Mint oil yields may be reduced if applications are made when the crop is 6 inches or taller. Do not use if minor mint injury is unacceptable. If tank mixing with other herbicides, test on small area prior to application to entire field to determine if mint injury is acceptable.
Site of action Group 4: synthetic auxin
Chemical family Phenoxy; phenoxyalkanoic acid

Toothache Grass *Ctenium aromaticum* (Walt.) Wood
Plant Symbol = CTAR

Photo by Jose Hernandez. Provided by ARS Systematic Botany and Mycology Laboratory

Uses
Livestock grazes toothache grass most readily during spring and summer.

Description
Grass Family (Poaceae). Toothache grass is a warm-season, perennial bunch grass. The height is between 2 and 3 feet. The leaf blade is 1/4 to 1/2 inch wide, 6 to 10 inches long, pale green on bottom, and darker green on top. The leaf sheath is mostly basal and shorter than internodes. The ligule is small membrane with short hair. The stem, when erect, has an enlarged base and contains a substance that deadens the tongue and gums when chewed. The seedhead is a curved spike with spikelets sessile on one side of rachis, giving it a comb-like appearance.

Distribution: For current distribution, please consult the Plant Profile page for this species on the PLANTS Web site.

Management
This grass responds to same management as major associated grasses. An abundance of this grass indicates good range condition on wet sites.

Establishment
Growth starts in early spring and again in October or November. The seed ripens in late May or early June. Occasionally, it grows in pure stands. Each plant produces many seed stalks. This grass produces an abundant seed crop the first growing season after a burn. It is adapted to wet, poorly drained, acid soils. Typical sites are flatwoods with clayey subsoil and sloughs, which have standing or slow-moving water following heavy rains.

Livestock grazes toothache grass most readily during spring and summer.

Status
Please consult the PLANTS Web site and your State Department of Natural Resources for this plant's current status, such as, state noxious status and wetland indicator values.

Chemical control of grass and grasslike weeds
Perennial grass weeds
Most perennial grass weeds cannot be controlled with selective herbicides in turf. Spot treatment with a nonselective herbicide such as glyphosate (Roundup™) is the most reliable means of removing these weeds from turf. Glyphosate is an especially effective herbicide for perennial grass weeds since it is translocated through stolons and rhizomes and leaves no harmful soil residual. This herbicide is most effective when applied to actively growing plants.

A common perennial grasslike weed, yellow nutsedge, can be removed selectively from turf with the herbicides halosulfuron (Sedgehammer™) or bentazon (Basagran™). Be sure to follow label directions and note restrictions for nontolerant species.

Summer annual grasses
Summer annual grass weeds are usually controlled with preemergence herbicides. These herbicides act by forming a chemical barrier in the soil prior to seed germination or emergence. The barrier prevents grass seedlings from emerging and developing normally.

Table 1. Some preemergence herbicides for the control of summer annual grasses.

Generic name	Trade name
Benefin	Lebanon Balan 2.5G
Benefin and trifluralin	Team
Bensulide	Bensumec
Bensulide + oxadiazon	Goosegrass/Crabgrass Control
Dithiopyr	Dimension
Oxadiazon	Ronstar
Pendimethalin	Pre-M, Pendulum, Halts
Prodiamine	Barricade
Siduron	Tupersan

You can use several preemergence herbicides to control summer annual grass weeds. Table 1 lists the chemical (generic) and trade names of some commonly used preemergence herbicides.

Several factors should be considered in choosing a preemergence herbicide. The first is the safety of the chemical for turfgrass species and cultivars. For example, oxadiazon may injure fine fescues, but it is generally safe on Kentucky bluegrass, ryegrass, and tall fescue. Most preemergence herbicides have long residual activity in the soil and may affect newly seeded turfgrasses. Thus, seeding of turfgrasses should be postponed for the amount of time specified on the manufacturer's label. Siduron is the only material that can be safely used during or immediately following seeding.

For maximum effectiveness, preemergence herbicides should be applied uniformly at the label recommended rates. These herbicides are more efficient when watered-in within two to three days of application.

The timing of preemergence herbicide applications is the most critical component of an effective chemical control program. As a general rule, the best time to apply preemergence materials is approximately 10 to 14 days prior to the expected germination period in spring. Crabgrass begins to germinate when soils are moist and the temperature in the upper inch of soil reaches 55° to 58° F at daybreak for four to five days. Forsythia flower petal fall is not a consistently reliable means of determining timing of crabgrass herbicide applications.

Postemergence control of crabgrass and some other summer annual weeds involves the use of chemicals that kill growing plants after they have appeared in the turf. Postemergence herbicides can be used to treat only those areas where summer annual grass weeds have emerged. Preemergence herbicides, on the other hand, are usually applied over the entire turf area since the applicator does not know where seeds are or if they are present.

For postemergence herbicides to be effective, crabgrass must be uniformly covered. Thus, these compounds should be applied only when crabgrass is visible in the stand. Table 2 lists the chemical and trade names of some commonly used postemergence herbicides for annual grass control.

Table 2. Some postemergence herbicides for the control of summer annual grasses.

Generic name	Trade name
Dithiopyr	Dimension
DSMA	Methar 30
Fenoxaprop-p-ethyl	Acclaim Extra
MSMA	MSMA Turf Herbicide
Quinclorac	Drive 75 DF Herbicide

The methanearsonates (MSMA and DSMA) act as contact herbicides. The most commonly used methanearsonate, MSMA, may injure desirable species at high temperatures (greater than 80° F), and repeat applications at specified intervals are necessary for complete control (see label). It is important not to water turf for 24 hours after application. MSMA is effective in controlling crabgrass under both adequate and low soil moisture levels.

Fenoxaprop-p-ethyl is a postemergence herbicide that is slowly translocated within the plant. It can effectively control tillered crabgrass with a single application. It is relatively safe on cool-season turfgrasses but may injure some Kentucky bluegrass cultivars, especially at high temperatures early in the season. It should not be applied if cool-season turfs show signs of drought stress. Fenoxaprop-p-ethyl is less effective when tank-mixed with phenoxy-type herbicides such as 2,4-D and MCPP.

Dithiopyr acts as a preemergence and postemergence herbicide. It provides postemergence control of crabgrass only up to the one-tiller stage of development, but it can be combined with fenoxaprop-p-ethyl when two or more tillers are present.

Quinclorac is a postemergence herbicide effective in controlling crabgrass and some broadleaf weeds. Optimum control of crabgrass is achieved when quinclorac is applied before development of the second tiller or when crabgrass plants have five or more tillers. In some cases, quinclorac does not provide complete control of crabgrass at the two-, three-, and four-tiller stages of development. In these situations, a second application may be required for complete control. Quinclorac can be mixed with other herbicides, including pendimethalin and phenoxy herbicides, to improve weed control. For best results, apply quinclorac in combination with a methylated seed oil according to directions on the label.

Western Yarrow *Achillea millefolium L. var. occidentalis* DC.
Plant Symbol = ACMIO

Other Common Names
Bloodwort, carpenter's weed, milfoil, soldiers' woundwort, western yarrow, woolly yarrow

Uses
Conservation: It is an early successional species that readily establishes on disturbed sites. Western yarrow is recommended for adding species diversity in native seed mixtures for rehabilitation of disturbed sites such as rangelands, minelands, roadsides, park and restoration areas, prairie reconstruction projects, and farm bill program conservation plantings. Secondary use is for ornamental application in pollinator friendly, low maintenance, or naturalized landscapes.

Forage: It is a food source for bighorn sheep, pronghorn antelope, and deer. Sage grouse, especially chicks, and other upland birds rely heavily on the foliage of western yarrow as a food source. Domestic sheep and goats derive a fair amount of forage value from western yarrow, while cattle and horses mostly graze the flower head. The volatile oils, alkaloids, and glycosides are considered toxic, but the plant is seldom overgrazed by foraging animals.

Ethnobotanic: Native Americans used western yarrow for many purposes, such as a tea to cure stomach ailments, a poultice on infected wounds, and as a mosquito repellant.

Status
Please consult the PLANTS Web site and your State Department of Natural Resources for this plant's current status (e.g. threatened or endangered species, state noxious status, and wetland indicator values).

Weediness
Western yarrow is not to be confused with the introduced, invasive plant, common yarrow (Achillea millefolium var. millefolium). Common yarrow has origins in Eurasia, the European continent, and the islands of Scandinavia. This introduced species is considerably different from western yarrow in that it has a much taller stature, aggressive vigor and weediness characteristics, and initiates a later sequence of flowering and seed ripening. Please consult with your local NRCS Field Office, Cooperative Extension Service office, or state natural resource or agriculture department regarding its status and use. Weed information is also available from the PLANTS Web site at plants.usda.gov.

Description
Western yarrow is a native, herbaceous perennial in the Aster Family. It is a very common wildflower that grows erect from creeping rootstocks, to a height mostly 10 to 36 in. (25 to 90 cm) tall. The leaves of western yarrow are densely hairy, and lacy and fern-like in appearance, as they are finely dissected into numerous, short and narrow divisions not over 0.04 in. (1 mm) wide--millefolium means a thousand leaves in Latin. Common yarrow leaves, in comparison, are smooth or only sparsely hairy; and the leaf segment is longer, more rounded, and lance-shaped. The somewhat rounded terminal clusters of flower heads of western yarrow are normally white to cream-colored and have an extended bloom period from May to September. For a current distribution map, please consult the Plant Profile page for this species on the PLANTS Web site.

Adaptation
Western yarrow is one of the most widely recognized and adaptable wildflowers in the western United States. Its range of distribution includes many habitats across Canada, the Great Plains, and the western United States. Western yarrow is very drought-tolerant and exhibits good survival in droughty conditions on gravelly loam and thin or sandy soils.

Establishment
Seed of western yarrow is non-dormant and readily germinates when spring planted at a very shallow depth. It tends to be less competitive in early development and becomes more so with age. Western yarrow produces very few flowers the establishment year, but will easily set seed in subsequent years. It is moderately rhizomatous, developing as a scattered colony that maintains a semi-evergreen state when dormant.

Weedy Characteristics
Yarrow is tolerant of a wide range of conditions, including drought and poor soil. The plant spreads mostly by the development of rhizomes, producing new plants from rhizome tips. When fragmented, rhizome parts will produce new plants, even from as deep as 12 inches within the soil. Its rhizomatous habit allows yarrow to tolerate frequent mowing. Yarrow also reproduces by seed, producing thousands of seeds per flowering stalk. The seeds are distributed by wind, and remain viable in the soil at least 9 years.

General Facts
Yarrow has been used for many medicinal purposes, including fever and pain relief, and wound poultices (thus the common names 'bloodwort' and 'soldier's woundwort'). It is a food source for some wildlife, and is attractive to insects. Although not often grazed by domestic cows or horses, yarrow contains substances which would be harmful if ingested in large amounts, and cows that graze it produce poor-tasting milk.

The plant is used in flower arrangements, and thye crushed leaves and flowers have a pungent fragrance. Yarrow has been used in erosion control projects, because of its rhizomatous growth habit.

Closely related western yarrow is a native to North America, and is almost indistinguishable from common yarrow, especially

Management
New seedings may need protection from trampling and some weed control during establishment. Western yarrow vigor, esthetics, and stand persistence after establishment may be sustained with properly timed grazing or defoliation of associated species. A well-fertilized lawn with soil that does not remain dry for long periods will have a competitive edge over yarrow. Digging and hoeing small patches of yarrow can be effective, but rhizomes must be completely removed for thorough control, as broken rhizomes can grow independently and produce new plants. Yarrow does not tolerate shade well, and will not thrive in the shade of healthy garden plants. For current chemical or
biological methods, consult your local state or county weed specialist.

Pests and Potential Problems
Inflorescences that are harvested for seed production often contain small quantities of insect larvae and numerous live insects. There is no apparent short- or long-term effect on the seed in any way. Many beneficial and pollinating insects, such as minute pirate bug (Orius), big-eyed bug (Geocoris), hoverflies (Syrphidae), and several tachnid flies (Archytas apicifer, Gymnosoma, Tricopoda pennipes, Cylindromia) are known to frequent yarrow plants. Pest insects include common leaf bugs (Lygus.) and flea beetles (Chrysomelidae). Root rot and mildew may occur in poorly drained soils.

Environmental Concerns
This plant is a common component of such ecological sites as shallow, silty, shallow to gravel, and silty steep. Associated species include western wheatgrass (Pascopyrum smithii), bluebunch wheatgrass (Pseudoroegneria spicata), prairie Junegrass (Koeleria macrantha), Sandberg bluegrass (Poa secunda), common gaillardia (Gaillardia aristata), big sagebrush (Artemisia tridentata), and prairie coneflower (Ratibida columnifera). Western yarrow is a pioneer species and considered an increaser where the forage resource has been over utilized. It is seldom regarded as a problem weed except on heavily disturbed, arable sites with favorable environmental conditions. Western yarrow should be considered noninvasive when used within a diverse plant community in its anticipated area of adaptation.

USE PESTICIDES WISELY: ALWAYS READ THE ENTIRE PESTICIDE LABEL CAREFULLY, FOLLOW ALL MIXING AND APPLICATION INSTRUCTIONS AND WEAR ALL RECOMMENDED PERSONAL PROTECTIVE GEAR AND CLOTHING. CONTACT YOUR STATE DEPARTMENT OF AGRICULTURE FOR ANY ADDITIONAL PESTICIDE USE REQUIREMENTS, RESTRICTIONS OR RECOMMENDATIONS.

NOTICE: MENTION OF PESTICIDE PRODUCTS IN THIS COURSE DOES NOT CONSTITUTE ENDORSEMENT OF ANY MATERIAL.

Yellow Rabbitbrush *Chrysothamnus viscidiflorus* (Hook.) Nutt. Plant Symbol = CHVI8

Photo credit Dave Powell USDA

Alternate Names
Crinitaria viscidiflora Hooker
Ericameria viscidiflora (Hook.) L.C. Anderson
Douglas rabbitbrush
Green rabbitbrush
Low rabbitbrush
Sticky-leaf rabbitbrush
Viscid rabbitbrush

Uses
Wildlife and livestock: Yellow rabbitbrush is browsed by large game and livestock. It is considered desirable fall forage for cattle, sheep, horses, elk and antelope, and spring forage for deer (Ogle and Brazee, 2009). It is a valuable forage especially during late fall and early winter after more desirable forage has been utilized (Tirmenstein, 1999). Palatability and usage vary between subspecies of yellow rabbitbrush (McArthuer et al., 1979).

Yellow rabbitbrush provides cover and nesting habitat for sage-grouse, small birds and rodents (Gregg et al., 1994). Black-tailed jackrabbits consume large quantities of yellow rabbitbrush during winter and early spring when plants are dormant (Curie and Goodwin, 1966). Yellow rabbitbrush provides late summer and fall forage for butterflies. Unpublished field reports indicate visitation from bordered patch butterflies (Chlosyne lacinia),

Mormon metalmark (Apodemia mormo), mourning cloak (Nymphalis antiopa), common checkered skipper (Pyrgus communis), and Weidemeyer's admiral (Limenitis weidemeyerii).

Restoration: Yellow rabbitbrush is a seral species which colonizes disturbed areas making it well suited for use in restoration and revegetation plantings. It can be established from direct seeding and will spread via windborne seed. It has been successfully used for revegetating depleted rangelands, strip mines and roadsides (Plummer, 1977).

Status

Please consult the PLANTS Web site and your State Department of Natural Resources for this plant's current status (e.g., threatened or endangered species, state noxious status, and wetland indicator values).

Description

General: Sunflower family (Asteraceae). Yellow rabbitbrush is a low- to moderate-growing shrub reaching mature heights of 20 to 100 cm (8 to 39 in) tall. The stems can be glabrous or pubescent depending on variety, and are covered with pale green to white-gray bark. The leaves are narrow and linear to oblong 1 to 6 cm (0.4 to 2.4 in) long and 0.5 to 8 mm (0.02 to 0.3 in) wide and often appear twisted. The flowers heads are borne in numerous compact to open terminal cymes. The flower heads are 5 to 7.5 mm (0.2 to 0.3 in) long and 2 to 4 mm (0.08 to 0.16 in) wide with glandular or pubescent bracts. The individual flowers are yellow 4 to 6 mm (0.16 to 0.25 in) long, producing a 4 mm (0.16 in) long, hairy achene (Welsh et al., 2003).

There are five recognized varieties of yellow rabbitbrush including varieties planifolius, lanceolatus, puberulus, axillaris and viscidiflorus which can be distinguished by leaf morphology, stem pubescence and distribution. Flora of North America (1993+) provides a taxonomic key for the separation of varieties.

Ethnobotany

Yellow rabbitbrush has been used by a variety of Native American peoples. Paiute Indians used yellow rabbitbrush to treat colds and coughs (Kelly, 1932), and the Hopi Indians used yellow rabbitbrush as a dermatological aid (Fewkes, 1896). The Gosiute and Paiutes used the latex from the roots as a chewing gum (Chamberlin, 1911; Mahar, 1953). Hopi and Navajo people used the flowers to create orange and yellow dye (Colton, 1974; Elmore, 1944).

Distribution: Yellow rabbitbrush is native to western North America. It has been found from British Columbia, south to California and east to Nebraska, Colorado, Montana and New Mexico. For current distribution, please consult the Plant Profile page for this species on the PLANTS Web site.

Habitat: Yellow rabbitbrush occurs in desert to semi-desert habitats in western rangelands. It is commonly associated with other rabbitbrush species (Chrysothamnus and Ericameria spp.) and sagebrush species (Artemisia spp.). Other associates include broom snakeweed (Gutierezi sarothrae), shadscale (Atriplex confertifolia), and winterfat (Krascheninnikovia lanata). Yellow rabbitbrush can also be found growing in pinyon-juniper (Pinus-Juniperus woodlands). Yellow rabbitbrush and other rabbitbrush species are often subdominant in sagebrush communities with rabbitbrush densities quickly increasing after heavy disturbance and then decreasing with time as sagebrush densities increase (Young and Evans, 1974).

Adaptation

Yellow rabbitbrush is adapted to coarse to medium well-drained soils in areas receiving (7 to 24 in) mean annual precipitation. It has fair salt tolerance and will grow in soils with a pH range 7.0 to 8.5 (USDA-NRCS, 2012). It is found at middle to high elevations from 800 to 3,350 m (2,600 to 11,000 ft) (Hitchcock and Cronquist, 1973).

Establishment
Yellow rabbitbrush does not exhibit dormancy and do not persist in the soil seed bank (James et al., 1991). Field establishment of yellow rabbitbrush is typically achieved with nursery grown plants or with fall dormant seedings. Seed should be broadcast or shallow drilled to no more than 3 mm (0.125 in) depth. The pure stand seeding rate is 0.5 lb/ac. For rangeland seedings the recommended rate in mixes is approximately 1/40 of a pound PLS per acre (Ogle et al., 2011). There are approximately 733,000 seeds/lb (USDA-NRCS, 2012). Bareroot and containerized materials can be transplanted in the fall or spring (McArthur and Stevens, 1994).

Management
Yellow rabbitbrush increases with overgrazing and is difficult to completely control (Whitson et al., 1996). It is susceptible to 2,4-D during periods of active growth and available moisture when herbicides will be translocated through the tissues to the dormant buds in the crown (James et al., 1991). Top removal practices such as mowing and burning are ineffective due to yellow rabbitbrush's ability to resprout from crown buds (James et al., 1991). If management objectives are to reduce yellow rabbitbrush, fire treatment is not generally recommended as it may result in the species becoming dominant.

Pests and Potential Problems
Mature yellow rabbitbrush plants are susceptible to infestations of the larvae of hairy yellow-marked buprestid (Acamaeodera pulchella) which bore tunnels through the stems resulting in plant death (Young and Evans, 1974).

Environmental Concerns
Yellow rabbitbrush will spread and can become weedy under high grazing and disturbance (Whitson et al., 1996).

Control
Please contact your local agricultural extension specialist or county weed specialist to learn what works best in your area and how to use it safely. Always read label and safety instructions for each control method. Trade names and control measures appear in this document only to provide specific information. USDA NRCS does not guarantee or warranty the products and control methods named, and other products may be equally effective.

Seeds and Plant Production
Seed can be collected by hand with racquets and hoppers, or mechanically with vacuum type harvesters, flail vacs and other seed strippers. Yellow rabbitbrush seed is difficult to clean and low purity levels are common in seed lots. Jorgensen and Stevens (1994) list acceptable purities of 10 to 15 percent. Long term seed storage of yellow rabbitbrush has been problematic. Seed viability of rubber rabbitbrush dropped from 80 to 14% when stored under dry storage conditions from the second to fifth year in storage (James et al., 1991).

Cultivars, Improved, and Selected Materials (and area of origin)
Wildland collected seed is available from commercial sources. There are currently no commercial releases of yellow rabbitbrush.

Chemical Control of Rabbitbrush (*Chrysothamnus* spp.)
2,4-D LV ester
Rate 3 lb ae/A
Time Apply when rabbitbrush has 3 inches of new spring growth.
Remarks Soil moisture should be above wilting coefficient. If Sandberg bluegrass has dried up or lost its color, soil is too dry for rabbitbrush active growth, and it is too late to spray.
Caution Avoid drift to sensitive crops.
Site of action Group 4: synthetic auxin
Chemical family Phenoxy acetic acid

Picloram (Tordon)

Rate 0.25 to 0.5 lb ae/A

Time Any time during the growing season.

Remarks A selective treatment that will not damage perennial grasses at the suggested rate.

Caution Most formulations are restricted-use herbicides. Do not contaminate water. Do not use in diversified crop areas. Potatoes, beans, and most other broadleaf crops are sensitive to picloram.

Site of action Group 4: synthetic auxin

Chemical family Pyridine

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NOTICE: MENTION OF PESTICIDE PRODUCTS IN THIS COURSE DOES NOT CONSTITUTE ENDORSEMENT OF ANY MATERIAL.

Basic Weed/Herb Control Section

Effective weed control usually results from a combination of cultural, mechanical, and chemical practices. The ideal combination for each field will depend on a number of considerations including: 1) the crop being grown, 2) the kinds of weeds, 3) the seriousness of the weed infestation, 4) the soil type, 5) the cropping system, and 6) the availability of time and labor.

Preventive weed control is the least expensive and the only foolproof method to stop invasions of weeds. If we don't have it now, let's not plant it. When purchasing plants or seeds make sure you know what you're buying. This is extremely important when purchasing plants or seeds by mail order or through the Internet. Be particularly wary of seed mixtures, completely read the product label and make sure you are familiar with all the species in the mix. Go native to make sure you aren't introducing current or potential noxious weeds. Reputable nurseries will be able to assist you in selecting native species of plants for your lawn, landscape, or garden. Master Gardeners are another source of information on the best species of plants to select for landscape or garden.

It is also important to prevent the accidental introduction of new invasive species. Make sure that compost, mulch, sod, fill soil, or any other amendment you use is free of weeds. Use a local source for these products.

Feed your livestock weed-free feed. Sometimes this is not possible during animal transport or for other reasons. Be certain to allow time for the animals to "clean out" the weed infested feed before putting them out on pasture or rangeland. The same is true of newly added cattle, horses, or other animals. Make sure you compost manure and bedding from the period during and just after feeding suspect feed. Check boats and off-road vehicles before leaving the area where you have used them. Weeds can be carried easily in water or mud so wash the vehicles immediately possible following use.

Even if preventative steps are taken, infestations can still occur. Be constantly on the watch for areas where you suddenly notice a new flush of vegetation. Early detection is critical to complete eradication of the weed.

Control efforts can easily be intensified and eradication a realistic goal. Weeds can be spread by animals or birds, but new infestations are most commonly due to human activities. Look for new species of weeds in areas where human activity is most common or along water ways.

What do you do once the infestation has been identified?

- Mark the perimeter of the area to delineate the infestation and determine if the infestation is increasing or decreasing once control measures are applied.
- Limit activity to and from the area to make sure seed, roots, and other parts aren't spread.
- Try to determine how the weed was introduced. If it appear due to logging, construction, or other activities scout similar sites in the area.
- Check horse or recreational vehicle trails in the area to determine spread.
- Check upstream and down stream if the infestation occurs along water ways.
- Select the appropriate control measures and apply them aggressively.
- Monitor the area constantly to determine the effectiveness of control measure. Seeds can lay dormant in the soil for 10 years or longer, continue monitoring for years after you've seen the last plant in the area.

Weed Prevention Steps

Key- Avoid weed establishment; eliminate individual survivors.

- Identify and map weed infestations; keep records over years.
- Recognize and eliminate new weeds before they multiply and establish.
- Employ sanitary procedures; prevent weed spread.
- Clean equipment between sites or infestations.
- Examine nursery plants, seed, and imported soil or media.
- Screen irrigation water where weed seed contaminates surface water transported in canals and rivers or stored in lakes or ponds.
- Control weeds and seed sources around the field or site.
- Establish county and state weed laws and noxious weed control programs.

When applying control measures, start with the most basic mechanical control. Dig out the plants if possible. Burn or compost the removed vegetation on site to prevent spreading them. Mowing can be effective, but mowing promotes low growth and low seed height which can't be prevented by mowing a second time. Also, equipment must be completely cleaned of vegetation and seed before removing from the site to prevent spreading the infestation. Mechanical control is expensive, but most effective and won't interfere with reestablishing desired vegetation on the site.

Mechanical Control

A combination of mechanical and chemical control can be very effective on woody invaders like trees or shrubs. The woody plant can be cut with hand ax or saw and the stump wiped with 2,4-D, Roundup™, or some other herbicide. It is important to apply the herbicide to the stump immediately after cutting. A delay of even a few minutes will reduce efficacy of the herbicide.

Normally, biological control of newly invasive species is not practical and should not be considered. Identifying and developing biological controls can take years and small infestations often can't sustain on the few plants present during the initial infestation. Thus, biological control, while effective on widespread infestation, is not a consideration in eradicating a species during the initial phases of an infestation.

Cultural Control is necessary following mechanical or chemical control. Digging and chopping cause soil disturbance and desired plants need to be reestablished before the invader can get a foot hold. The same is true of chemical control, the desired vegetation must be reestablished. Moreover, you must remember that the invader was able to gain a toehold under the management regime that had been in place on that land. Consider plant species, fertilization, and other cultural aspects of weed control.

Mechanical Summary

Weed debris turned under; annual weeds controlled; perennial weeds suppressed if this practice is repeated every 10 to 14 days.

Cultural Practices

Cultural practices that are optimum for crop growth should be followed. These practices include adequate fertility, optimum stands and row width, and proper seeding date. Tillage operations, if used, should be timed to destroy weeds. Tilling the soil immediately before planting will kill weeds that have germinated, thus giving the crop a competitive advantage and often improving weed control from chemicals that do not control weeds that have germinated.

Early cultivations when weeds are small are most effective. Use a rotary hoe, harrow, or cultivator as soon as weeds begin emerging and are in the "white stage," even if herbicides have been applied. Set cultivators for shallow operation to avoid crop root pruning and to reduce the number of weed seeds brought to the surface. Throw enough soil into the row to cover small weeds. Shallow cultivation should be repeated as necessary to control newly germinated weeds.

Mowing is an effective weed control practice in perennial forage crops and non-cropland areas. To be effective, mowing must be done before seeds are formed which means you must mow by the time weeds are in the bud stage or just beginning to bloom. Earlier mowing will reduce weed competition and improve crop yield more than later cutting.

Cultural Summary *Integrate numerous components to minimize impact of weeds.*
1. Select manageable fields (identify weeds and choose crop according to feasibility of weed management strategies; e.g., avoid planting onions into perennial weeds).
2. Rotate crops (disrupt weed life cycles or suppress weeds in competitive crop followed by planting a noncompetitive crop).
3. Plant winter cover or competitive fallow crops in rotation to improve soils and crop management (specific cultivars are being evaluated).
4. Consider legumes to supplement nitrogen requirements.
5. Consider specific varieties of cereals with natural plant toxins (allelopathy); vegetation must remain uniform on soil surface; either perennial or large-seeded crops can be planted through undisturbed mulch.
6. Consider crops or cultivars that winter kill after vigorous growth during fall to avoid springtime controls.
7. Alter planting dates (plant for maximum growth or delay planting to control first weed flush).
8. Transplant slow-growing crops.
9. Band or spot fertilizer beside plant or seed (reduces availability to surface-germinating weeds).
10. Time additional side-dressings for maximum crop growth or to minimize weeds.
11. Develop crop canopy that shades weeds, suppresses weed germination.
12. Select crops or varieties that form canopy quickly.
13. Space plants in equidistant (triangular) arrangements and vary density depending on crop management constraints or harvest requirements (e.g., product quality).
14. Interplant crops in space and time (consider mechanical limitations in commercial plantings).
15. Combine broadleaf and taller, narrowleaf crops (corn or beans with pumpkins).
16. Relay plantings or harvest short-duration crops within longer maturing crops (bush beans with corn; cucumbers with peppers; tree crops with vegetables).
17. Manage appropriate living mulch (grass or legume) between perennial crop rows.
Improve pasture management by reseeding and/or fertilizing with or without control measures to reduce weed infestation (weeds often are a symptom of poor management).

Apply Mulch, Black Plastic or Geo-textiles
Organic materials: Straw (may reduce available N when decomposing; often infested with weed seed). Sawdust (avoid vertebrate pests by maintaining mulch-free circle around tree; perennial weeds become a serious problem).
Bark mulch: Newspapers (during emergence, rhizomes of some perennial weeds become disoriented when penetrating 6 to 16 layers of overlapped newspaper).
Plastic: Black excludes light, controls most annual weeds.
Clear plastic acts like greenhouse; poor weed control. New wavelength-selective plastics for pest management (research is progressing).
Geo-textiles (available at ag and garden supply stores): **Spunbonded fabrics** (nonwoven): lightweight, extruded polypropylene fibers; requires mulch cover due to moderate UV light sensitivity; weed roots and rhizomes can penetrate fabric unless removed before establishment; cheapest option.
Woven fabrics: moderate-weight polypropylene fibers woven into a mat; can be used without mulch cover due to UV light stability; weed roots and rhizomes can penetrate fabric although tightness of weave can prevent some weeds; moderate cost.
Laminates: highly porous, dense poly film bonded to capillary fibers with a pressed, nonwoven bottom layer. Surface is slick and causes rapid wetting and drying to prevent weed establishment except for perennial rhizomes which can penetrate the laminate; most expensive geo-fabric.
Solarization: Thin plastic secured tightly over loose, moist soil for 10 to 12 weeks will suppress weed infestations and other pests during hot season.

2, 4-D

Disclaimer* Herbs are not a replacement for pharmaceutical drugs. If you are unfamiliar with how to use an herb, ask your herbalist or healthcare professional before using the herb. Never use any of these herbs unless you have been personally trained by an herbalist or healthcare professional. Herbs can cause death or serious illness.

USE PESTICIDES WISELY: ALWAYS READ THE ENTIRE PESTICIDE LABEL CAREFULLY, FOLLOW ALL MIXING AND APPLICATION INSTRUCTIONS AND WEAR ALL RECOMMENDED PERSONAL PROTECTIVE GEAR AND CLOTHING. CONTACT YOUR STATE DEPARTMENT OF AGRICULTURE FOR ANY ADDITIONAL PESTICIDE USE REQUIREMENTS, RESTRICTIONS OR RECOMMENDATIONS.

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Topic 4 Herbs and Related Invasive Species
Post Quiz Answers at the rear of Glossary

What Is roundup ready alfalfa?

1. The introduction of Roundup Ready alfalfa provides a new option for weed management in alfalfa. Roundup Ready alfalfa incorporates _____to the herbicide glyphosate (Roundup, Touchdown, Glyphomax, etc.) into the alfalfa plant. Similar to other Roundup Ready crops on the market today such as corn and soybean, a single bacterial gene that modifies 5-enolpruvylshikimate-3-phosphate (EPSP) synthase has been inserted into the alfalfa plant to allow resistance to glyphosate.

How do I use Roundup Ready Alfalfa?

2. Roundup Ready alfalfa management is identical to conventional alfalfa management in all respects except_____. Roundup Ready alfalfa can be planted in the spring or late summer using standard alfalfa establishment practices. Roundup Ready alfalfa should be seeded at typical rates while the seedbed may be prepared through tillage or if suitable, through no-till.

Glyphosate Stewardship

3. Glyphosate resistance management should always be implemented when using glyphosate-resistant crops, such as Roundup Ready alfalfa. Repeated applications of any herbicide, including glyphosate, may result in herbicide-resistant weeds. Once _____become established within a field, the herbicide becomes ineffective against those weeds that are resistant.

4. Systemic (translocated) herbicides can be effective on herb Robert, especially if combined with monitoring for surviving plants. Chemical control can be quite effective if herb Robert has already established a monoculture on a site. Glyphosate (Roundup™) is most commonly used. However, herb Robert often occurs initially as part of a mosaic alongside_____. In these situations, alternative control methods that have the ability to target individual plants can more successfully meet all goals of a project.

5. Hand-pulling can be an effective method of controlling isolated, small populations of stiltgrass; however, it is rarely practical once stiltgrass becomes well-established. Hand-pulling is most effective _____before seeds mature.

6. Spearmint is a _____that grows from 30 to 100 cm tall. The entire plant has a strong, pleasant, minty smell. Stems are erect, branched, glabrous, grooved, and four-angled. Leaves are ovate to lanceolate, 2 to 7 cm long, 5 to 25 mm wide, pointed at the tips, and rounded at the bases with toothed margins. They are mostly glabrous, although they may be hairy on the main veins of the lower surfaces. They are sessile or have petioles less than 3 mm long. Inflorescences are dense, terminal, 3 to 12 cm long, and 5 to 10 mm wide.

7. Grass Family (Poaceae). Toothache grass is_____. The height is between 2 and 3 feet. The leaf blade is 1/4 to 1/2 inch wide, 6 to 10 inches long, pale green on bottom, and darker green on top. The leaf sheath is mostly basal and shorter than internodes. The ligule is small membrane with short hair. The stem, when erect, has an enlarged base and contains a substance that deadens the tongue and gums when chewed. The seedhead is a curved spike with spikelets sessile on one side of rachis, giving it a comb-like appearance.

8. The methanearsonates (MSMA and DSMA) act as_____. The most commonly used methanearsonate, MSMA, may injure desirable species at high temperatures (greater than 80° F), and repeat applications at specified intervals are necessary for complete control (see label). It is important not to water turf for 24 hours after application. MSMA is effective in controlling crabgrass under both adequate and low soil moisture levels.

9. Fenoxaprop-p-ethyl is a postemergence herbicide that is slowly translocated within the plant. It can effectively control tillered crabgrass with a single application. It is relatively safe on cool-season turfgrasses but may injure some Kentucky bluegrass cultivars, especially at high temperatures early in the season. It should not be applied if cool-season turfs show signs of drought stress. Fenoxaprop-p-ethyl is less effective when tank-mixed with phenoxy-type herbicides such as_____.

10. Quinclorac is a _____effective in controlling crabgrass and some broadleaf weeds. Optimum control of crabgrass is achieved when quinclorac is applied before development of the second tiller or when crabgrass plants have five or more tillers. In some cases, quinclorac does not provide complete control of crabgrass at the two-, three-, and four-tiller stages of development. In these situations, a second application may be required for complete control.

Topic 5 Vine Section Alien Plant Invaders

Buffalo Gourd, Stinking Gourd, Calabacilla Loca, Missouri Gourd, Foetid Wild Pumpkin *Cucurbita foetidissima* Kunth in H.B.K.

Buffalo Gourd is a perennial and can be found growing in waste places, fields, and along roadsides. It is a low growing vine that can reach a length of 20 feet. The large, yellow flowers open in the mornings and are 3 to 4 inches long and 1 to 2 inches wide. The gray-green leaves are a narrow triangle shape that tend to fold upward, parallel to the midvein. The fruit is a gourd that is dark green with lighter green stripes when immature. It is about 2 to 3 inches in diameter at maturity and turns a yellow color.

Buffalo Gourd blooms from May to September. It is a perennial, reproducing by seed and roots. Taproot is yellow inside, carrotlike, very thick and fleshy, often more than 6 inches (15 cm) across, sometimes over 5 feet (1.5 m) long. Stems are trailing and rooting at joints, 15 to 30 feet (4.5 to 9 m) long, stout, angled, ridged, rough-hairy, and many-branched. Leaves are thick, simple, sharply toothed, 4 inches to 1 foot (10 to 30 cm) long, ovate, long-pointed, rough above, gray-hairy beneath, with strong, rough-hairy petioles. Flowers are bright yellow, deeply 5-lobed, 3 to 4 inches (7.5 to 10 cm) long and nearly as broad, in the leaf axils.

Male and female flowers are separate but on the same plant. Fruit is globular, 3 inches (7.5 cm) long, with yellow and green markings and a hard, smooth rind. Seeds are numerous, oval, flattened, similar to pumpkin seed but about half as large, and a light straw-color. This plant is found on dry, sandy soil in fields and waste places, and along fence rows. The entire plant has an offensive odor, especially when bruised.

Chinese Wisteria *Wisteria sinensis* (Sims) DC.
Japanese Wisteria *Wisteria floribunda* (Willd.) DC.

NATIVE RANGE: China and Japan

DESCRIPTION: Chinese and Japanese wisteria are exotic, showy, woody ornamental vines in the pea family, or Fabaceae. These vigorous vines can climb trees, apparently limited only by the height of the tree, and have been observed to reach 65 feet. Unlike American wisteria (*Wisteria frutescens*), native to the southeastern U.S., which flowers June through August, and produces a non-hairy seed pod 2-4 inches long, both exotic wisterias flower in the springtime (April-May) and produce a velvety seed pod. The fuzzy brown seed pods are 4-6 inches long, narrowed toward the base, with constrictions between the seeds. Stems of the exotic wisterias can grow to 15 inches in diameter in older plants. White-barked Japanese wisteria vines twine clockwise around the host plant and Chinese wisteria twines counter-clockwise. The compound leaves, consisting of 7-13 (Chinese) or 13-19 (Japanese) smaller leaf units, called leaflets, are about 1 foot long and alternate along the stem. Fragrant, violet to blue-violet flowers, ½ to 1 inch long, occur in showy, pendulous clusters that hang gracefully from the twining stems.

ECOLOGICAL THREAT: Exotic wisterias impair and overtake native shrubs and trees through strangling or shading. Climbing wisteria vines can kill sizable trees, opening the forest canopy and increasing sunlight to the forest floor, which in turn favors its aggressive growth. Chinese and Japanese wisterias are hardy and aggressive, capable of forming thickets so dense that little else grows.

DISTRIBUTION IN THE UNITED STATES: Japanese and Chinese wisteria are found extensively throughout the eastern states.

HABITAT IN THE UNITED STATES: The ideal habitat for exotic wisterias is in full sun, but established vines will persist and reproduce in partial shade. Vines often climb surrounding vegetation and structures toward sunlight. Wisteria tolerates a variety of soil and moisture regimes but prefers loamy, deep, well drained soils. Infestations are commonly found along forest edges, roadsides, ditches, and rights-of-way.

BACKGROUND: Chinese wisteria was brought to the U.S. from China in 1816 and Japanese wisteria was introduced from Japan around 1830. Both were brought in as ornamentals. They have been grown extensively in the southern U.S. as decorative additions to porches, gazebos, walls, and gardens. Most infestations in natural areas are a result of escapes from landscape plantings.

BIOLOGY & SPREAD: Exotic wisterias are long-lived, some vines surviving 50 years or more. Vegetative reproduction is their primary means of expansion. Numerous stolons, or above-ground stems, develop roots and shoots at short intervals. Abundant seeds may also be produced if conditions are favorable, but flower buds are susceptible to winter kill. In riparian habitats, seeds may be carried downstream in water for great distances.

CURRENT MANAGEMENT APPROACHES: The only practical methods currently available for control of exotic wisterias are mechanical and chemical. Cut climbing or trailing vines as close to the root collar as possible.

This technique, while labor intensive, is feasible for small populations, as a pretreatment for large impenetrable infestations, or for areas where herbicide use is not desirable. Wisteria will continue to resprout after cutting until its root stores are exhausted. For this reason, cutting should begin early in the growing season and, if possible, sprouts cut every few weeks until autumn. Cutting will stop the growth of existing vines and prevent seed production. However, cut vines left coiled around trunks may eventually girdle trees and shrubs as they continue to grow and increase in girth. For this reason, the vines should be removed entirely or at least cut periodically along their length.

Grubbing, removal of entire plants from the roots up, is appropriate for small initial populations or environmentally sensitive areas where herbicides cannot be used. Using a Pulaski, weed wrench or similar digging tool, remove the entire plant, including all roots and runners. Juvenile plants can be hand pulled, depending on soil conditions and root development. Any portions of the root system not removed may resprout. All plant parts (including mature fruit) should be bagged and disposed of in a trash dumpster to prevent reestablishment.

Cut stump treatment, using a systemic herbicide, is effective in areas where vines are established within or around desirable native plants or where they have grown into the canopy. This treatment is effective as long as the ground is not frozen. Cut the stem as close to ground level as possible. Immediately apply a 25% solution of glyphosate (e.g., Roundup) or triclopyr (e.g., Garlon) and water to the cross section of the stem. Re-treatment with a foliar application of glyphosate may be necessary for any sprouts.

Use foliar spray herbicide treatments to control large infestations of exotic wisterias. It may be necessary to precede foliar applications with stump treatments to reduce the risk of damaging non-target species. Apply a 2% concentration of glyphosate (e.g. Round Up) or triclopyr (e.g. Garlon) and water, plus a 0.5% non-ionic surfactant to thoroughly wet all foliage. Chlorpyralid (e.g. Transline) is effective at a concentration of 0.5% and is selective to plants in the aster, buckwheat, and pea families. Caution should be taken with chlorpyralid as groundwater pollution through leaching can be a problem with certain soil types. Do not apply spray so heavily that herbicide drips off the leaves. Glyphosate is a non-selective systemic herbicide that may kill non-target plants that are only partially contacted by spray. Triclopyr is selective to broadleaved species and is a better choice if native grasses are present. Ambient air temperature should be above 65ºF for all foliar treatments.

For more information on the management of exotic wisterias, please contact:
Kris Johnson, Great Smoky Mountains National Park, Gatlinburg, TN (kris_johnson@nps.gov)

SUGGESTED ALTERNATIVE PLANTS: There are a variety of creeping or climbing vines native to the eastern U.S. that are good alternatives to the invasive exotic wisterias. Some examples include American wisteria (*Wisteria frutescens*), trumpet creeper (*Campsis radicans*), trumpet honeysuckle (*Lonicera sempervirens*), Dutchman's pipe (*Aristolochia macrophylla*), and crossvine (*Bignonia capreolata*). Contact your local native plant society for information on sources of these and other native plants.

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Climbing Euonymus *Euonymus fortunei* (Turcs.) Hand.-Mazz.

NATIVE RANGE: China

DESCRIPTION: Climbing euonymus, also known as wintercreeper, Emerald'n Gold, and Gaiety, is an evergreen, clinging vine in the staff-tree (Celastraceae) family. It can form a dense groundcover or shrub to 3 feet in height, or climb 40-70 foot high vertical surfaces with the aid of aerial roots. Dark green, shiny, egg-shaped leaves, from 1 - 2 1/2 inches long, with toothed margins and silvery veins, occur in pairs along the stems. Stems are narrow, minutely warty, and have abundant rootlets or trailing roots. Clusters of inconspicuous green-white flowers are produced on a long stalk from June to July and are followed in the autumn by pinkish to red capsules that split open to expose seeds adorned with a fleshy orange seed coat, or aril.

ECOLOGICAL THREAT: Traits that make climbing euonymus a desirable ornamental plant, such as its rapid growth, evergreen nature, and tolerance of harsh conditions, also make euonymus a threat to natural areas. Climbing euonymus can outcompete native vegetation by depleting soil moisture and nutrients, blocking sunlight, and by forming a dense vegetative mat that impedes the growth of seedlings of native species. Vines on trees continue climbing and can eventually overtop them, covering the leaves and preventing photosynthesis.

DISTRIBUTION IN THE UNITED STATES: Climbing euonymus is currently scattered throughout the eastern U.S. in populated areas.

HABITAT IN THE UNITED STATES: Climbing euonymus tolerates a variety of environmental conditions, including poor soils, full sun to dense shade, and a wide pH range. It does not do well in heavy, wet soils. Natural forest openings resulting from wind throw, insect defoliation or fire are vulnerable to invasion and provide conditions for satellite populations of climbing euonymus to get started.

BACKGROUND: Climbing euonymus was introduced into the U.S. in 1907 as an ornamental ground cover.

BIOLOGY & SPREAD: Climbing euonymus spreads vegetatively with the help of lateral shoots produced along its long main branches and by new plants that emerge from rootlets also produced along the stem at short intervals. Vines climb rocks, trees, and other supporting structures. Flowers formed in the summer produce mature fruits by fall that are equipped with fleshy edible structures (arils) that are fed on by birds and other wildlife which disperse it. Climbing euonymus also escapes from neglected gardens and is carried by water to undisturbed forest and riparian areas.

CURRENT MANAGEMENT APPROACHES: A variety of mechanical and chemical methods are available for management of climbing euonymus. Grubbing, a rather labor intensive method, is effective for small populations or environmentally sensitive areas where herbicides cannot be used. Using a Pulaski or similar digging tool, remove the entire plant, including all roots and runners. Juvenile plants can be hand-pulled when the soil is moist and root systems are small.

Any portions of the root system remaining may resprout. All plant parts including stem fragments and mature fruits should be bagged and disposed of in a trash dumpster to prevent re-establishment.

Cut stem treatment, using systemic herbicides applied to freshly cut stems, is effective in areas where vines are well established on or around non-target plants, or where they have grown into tree canopies or other vertical surfaces. Cut the stem as close to the ground as possible and immediately apply a 25% solution of glyphosate (e.g., Roundup) or triclopyr (e.g., Garlon) and water to the cut stem. This procedure is effective at temperatures as low as 40°F.

Subsequent foliar application of these herbicides may be required. Cutting without the application of herbicides is generally not recommended because this will lead to root sprouting.

Foliar applications of herbicide can be used to control large populations. It may be necessary to precede foliar sprays with cut stem treatments to reduce the risk of damage to non-target plants. Apply a 2% solution of glyphosate or triclopyr and water plus a 0.5% non-ionic surfactant to thoroughly wet all foliage but not so heavily that it drips off leaves where it may affect desirable plants. Glyphosate is a non-selective systemic (i.e., travels through the plant vessels) herbicide that may kill even partially sprayed plants. Triclopyr is selective to broad leaf species and is a better choice if desirable native grasses are present. Ambient air temperature should be above 65°F.

For more information on the management of climbing euonymus, please contact:
Kris Johnson, Great Smoky Mountains National Park, Gatlinburg, TN (kris_johnson@nps.gov)

SUGGESTED ALTERNATIVE PLANTS: There are a variety of native creeping or climbing vines that make good alternatives for climbing euonymus. Some examples from the eastern U.S. include trumpet creeper (*Campsis radicans*), Dutchman's pipe (*Aristolochia macrophylla*), crossvine (*Bignonia capreolata*), trumpet honeysuckle (*Lonicera sempervirens*), American bittersweet (*Celastrus scandens*), and American wisteria (*Wisteria frutescens*), our only native wisteria*.

*NOTE: When purchasing or planting wisteria, make certain it is the native American wisteria (*Wisteria frutescens*) and not exotic Chinese wisteria (*Wisteria sinensis*) or Japanese wisteria (*Wisteria floribunda*), both of which are aggressive exotic invaders of natural areas and are difficult to control.

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English Ivy *Hedera helix* L.

NATIVE RANGE: Europe, western Asia, and northern Africa

DESCRIPTION: English ivy is an evergreen climbing vine in the ginseng family (Araliaceae). Vines attach to the bark of trees, brickwork, and other surfaces by way of numerous, small rootlike structures, which exude a glue-like substance. Older vines are known to reach a foot in diameter. Leaves are dark green, waxy, somewhat leathery, and are arranged alternately along the stem. English ivy has many recognized leaf forms, the most common being a 3-lobed leaf with a heart-shaped base. Leaves in full sun are often unlobed, oval and have wedge-shaped bases. Umbrella-like clusters of small, greenish-white flowers appear in the fall if sufficient sunlight is available. Fruits mature in Spring and are black with a fleshy outer covering enclosing one to a few hard, stone-like seeds.

NOTE: Compounds in English ivy are somewhat toxic and include glycosides that cause vomiting, diarrhea, nervous conditions and dermatitis in sensitive individuals. This characteristic helps ensure spread of the seeds by many native songbirds that are attracted to the black berries in Spring when other food sources are limited.

ECOLOGICAL THREAT: English ivy is an aggressive invader that threatens all vegetation levels of forested and open areas, growing along the ground as well as into the forest canopy. The dense growth and abundant leaves, which spring from the stems like small umbrellas, form a thick canopy just above the ground, and prevent sunlight from reaching other plants. Similarly, vines climbing up tree trunks spread out and surround branches and twigs, preventing most of the sunlight from reaching the leaves of the host tree. Loss of host tree vigor, evident within a few years, is followed by death a few years later. The added weight of vines makes infested trees susceptible to blow-over during storms. English ivy also serves as a reservoir for bacterial leaf scorch (*Xylella fastidiosa*), a plant pathogen that is harmful to native trees such as elms, oaks, and maples. English ivy is a popular plant, recommended by Cooperative Extension offices for use as a low maintenance alternative to lawns. It is widely used by homeowners, horticulturists, landscape contractors, parks departments and others desiring a fast-growing, low maintenance, evergreen groundcover. Once established at a site, English ivy can be expected to move beyond its intended borders into neighboring yards, parks and other lands, either by vegetative means or by seed.

DISTRIBUTION IN THE UNITED STATES: English ivy occurs in at least 26 states and the District of Columbia, where it is one of the most abundant and widespread invasive plants.

HABITAT IN THE UNITED STATES: English ivy infests woodlands, forest edges, fields, hedgerows, coastal areas, salt marsh edges, and other upland areas, especially where some soil moisture is present. It does not grow well in extremely wet conditions and is often associated with some form of land disturbance, either human-caused or natural.
BACKGROUND: English ivy was probably first introduced to the US by European immigrants and is widely sold as an ornamental plant for landscapes throughout the US.
BIOLOGY & SPREAD: English ivy reproduces vegetatively and by seed, which is dispersed to new areas primarily by birds, including English house sparrows, European starlings, robins, Stellar jays, and cedar waxwings. New plants grow easily from cuttings or from stems making contact with the soil.

CURRENT MANAGEMENT APPROACHES: Several effective methods of control are available for English ivy, including chemical and non-chemical, depending on the extent of the infestation, the amount of native vegetation on-site, and available time and labor.
Manual and Mechanical. Vines growing as groundcover can be pulled up by hand, with some difficulty, and left on-site or bagged and disposed of as trash. Vines climbing up into the tree canopy are more difficult to manage. First, vines should be cut at a comfortable height to kill upper portions and relieve the tree canopy. A large screw driver or forked garden tool can be used to pry and snap the vines away from the tree trunks. Vines can be cut using an axe or, with more difficulty, using a pruning saw. Rooted portions of vines will remain alive and should be pulled and repeatedly cut. Because cutting will likely promote further growth from the base, vigilance is required to ensure long term control.

Chemical. The systemic herbicide triclopyr (e.g., Garlon) is absorbed into plant tissues and carried to the roots, effectively killing the entire plant in place.
Foliar applications: From summer to fall, apply a 2.5% mixture of triclopyr amine (Garlon 3A) in water to the leaves or cut first, allow to re-grow, and apply the same mix to new foliage. Herbicide will also be absorbed through the stem bark for additional effect.
Basal bark applications: A higher rate (15-30%) of triclopyr ester (Garlon 4) may also be applied to stems of vines growing up trees but there is a possibility that the herbicide will be absorbed into the host tree, depending on the thickness of the host tree's bark and the penetration of English ivy rootlets.

Because English ivy is an evergreen vine, and remains active during the winter, herbicide applications can be made to it any time of year as long as temperatures are above 55 or 60°Fahrenheit for a few days. Fall and winter applications will avoid or minimize impacts to many native plant species. Repeat herbicidal treatments are likely to be needed and follow-up monitoring should be conducted to evaluate the success of treatments. Herbicidal contact with desirable plants should always be avoided. In areas where spring wildflowers or other native plants are interspersed, application of herbicides should be conducted prior to their emergence, or delayed until they have died back.
Biological control. There are no biological controls currently available for English ivy.

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Fiveleaf Akebia *Akebia quinata* (Houtt.) Dcne.

NATIVE RANGE: Central China to Korea and Japan.

DESCRIPTION: Akebia quinata, also known as chocolate vine, is a twining woody vine in the mostly tropical Lardizabalaceae family. It grows as either a twining vine or vigorous groundcover and has slender, rounded stems that are green when young and brown at maturity. The palmate (like a hand) leaves of akebia alternate along the stem and are divided into five, or sometimes fewer, approximately equal parts called leaflets, whose small stems meet at a central juncture. Leaflets are generally long oval in shape, 1½ to 3 inches long and emerge with a purplish tinge, becoming blue-green at maturity. Flowers are unusual, chocolate-purple colored, and fragrant, about 1 inch across, and appear in late March to early April; they are often concealed by new foliage. Fruits are purple-violet, flattened, sausage-like pods, 2 1/4 to 4 inches in length that ripen in late September to early October. The inside of the pod has a whitish pulpy core with many tiny black seeds. Fiveleaf akebia is deciduous in cooler climates but may remain evergreen in the warmer regions, such as Louisiana.

ECOLOGICAL THREAT: Fiveleaf akebia grows so quickly that, if left unmanaged, it can kill off existing ground level vegetation, understory shrubs and trees, and even some canopy trees, by overtopping and smothering them. Once established, its dense growth prevents seed germination and seedling establishment of native plants.

DISTRIBUTION IN THE UNITED STATES: Fiveleaf akebia is found in 16 states in the eastern U.S., from Michigan to Connecticut, south to Georgia. Although it is not listed as occurring in South Carolina, this is probably an oversight.

HABITAT IN THE UNITED STATES: Akebia is shade and drought tolerant and can invade many types of habitats. Its growth appears to be restricted only by the height of the object it is entangling.

BACKGROUND: Fiveleaf akebia was brought to the United States in 1845 as an ornamental and has since naturalized in the warmer climates.

BIOLOGY & SPREAD: Akebia spreads primarily by vegetative means and is capable of growing twenty to forty feet in a single growing season. Fruits are not always produced and the seeds of akebia are not known to be carried by wind or insects. While birds may play a role in seed dispersal, fiveleaf akebia is vectored primarily through inadvertent activities of humans.

CURRENT MANAGEMENT APPROACHES: Small infestations of fiveleaf akebia can be controlled mechanically. Because of its extremely rapid growth, cutting will need to be repeated throughout the season. At a minimum, akebia should be cut back to the ground at the end of the summer. Akebia vines may also be dug up, removing as much of the roots as possible. To ensure its complete removal, regular monitoring and repeated cutting, digging or pulling is necessary.

For large infestations, use of a labeled systemic herbicide, such as glyphosate (e.g., Roundup) or triclopyr (e.g., Garlon), is probably the most effective method to control akebia. An herbicidal soap, such as pelargonic acid (e.g., Scythe), which provides a burndown of plant tissues, may also provide some control.

The latter product may also provide enhanced uptake of certain systemic herbicides, such as glyphosate. Be sure to avoid drift onto or direct spray of desirable plant species during herbicide applications.

SUGGESTED ALTERNATIVE PLANTS: Some native alternative vines for the eastern U.S. include trumpet honeysuckle (*Lonicera sempervirens*), cross vine (*Bignonia capreolata*), trumpet creeper (*Campsis radicans*), or Dutchman's pipe (*Aristolochia durior*). Contact your local native plant society for other suggestions.

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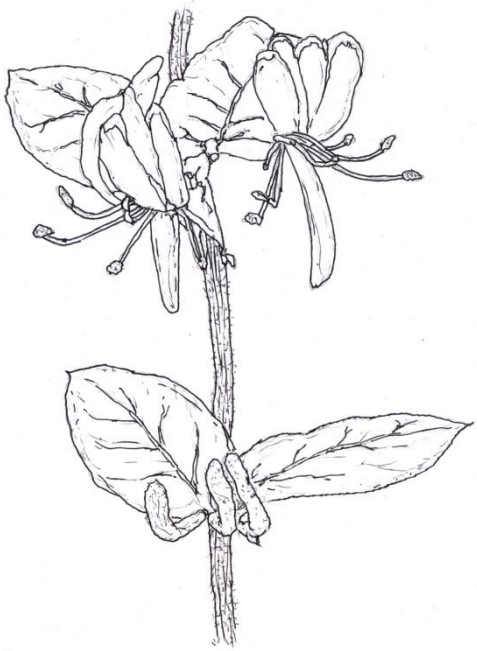
Japanese honeysuckle *Lonicera japonica* Thunb.



JAPANESE HONEYSUCKLE

NATIVE RANGE: Japan and Korea

DESCRIPTION: Japanese honeysuckle, a member of the honeysuckle family (Caprifoliaceae), is a perennial vine that climbs by twisting its stems around vertical structures, including limbs and trunks of shrubs and small trees. Leaves are oblong to oval, sometimes lobed, have short stalks, and occur in pairs along the stem. In southern and mid-Atlantic states, Japanese honeysuckle often remains evergreen – its leaves remain attached through the winter. In colder northern climates, the leaves may fall off after exposure to prolonged winter temperatures. Flowers are tubular, with five fused petals, white to pink, turning yellow with age; they are very fragrant, and occur in pairs along the stem at leaf junctures. Stems and leaves are sometimes covered with fine, soft hairs. Japanese honeysuckle blooms from late April through July and sometimes into October. Small black fruits are produced in autumn, each containing 2-3 oval to oblong, dark brown seeds about 1/4 inch across.

ECOLOGICAL THREAT: In North America, Japanese honeysuckle has few natural enemies which allows it to spread widely and out-compete native plant species. Its evergreen to semi-evergreen nature gives it an added advantage over native species in many areas. Shrubs and young trees can be killed by girdling when vines twist tightly around stems and trunks, cutting off the flow of water through the plant. Dense growths of honeysuckle covering vegetation can gradually kill plants by blocking sunlight from reaching their leaves. Vigorous root competition also helps Japanese honeysuckle spread and displace neighboring native vegetation.

DISTRIBUTION IN THE UNITED STATES: Japanese honeysuckle occurs across the southern U.S. from California to New England and the Great Lakes region. Escaped populations also occur in Hawaii. Severe winter temperatures and low precipitation may limit its distribution in northern latitudes and in the West, respectively.

HABITAT IN THE UNITED STATES: A ubiquitous invader, Japanese honeysuckle thrives in a wide variety of habitats including fields, forests, wetlands, barrens, and all types of disturbed lands.

BACKGROUND: Japanese honeysuckle was introduced to the U.S. in the early to mid-1800's as an ornamental plant, for erosion control, and for wildlife forage and cover. Its highly fragrant flowers provide a tiny drop of honey-flavored nectar enjoyed by children.

BIOLOGY & SPREAD: Growth and spread of Japanese honeysuckle is through vegetative (plant growth) and sexual (seed) means. It produces long vegetative runners that develop roots where stem and leaf junctions (nodes) come in contact with moist soil. Underground stems (rhizomes) help to establish and spread the plant locally. Long distance dispersal is by birds and other wildlife that readily consume the fruits and defecate the seeds at various distances from the parent plant.

CURRENT MANAGEMENT APPROACHES: Several effective methods of control are available for Japanese honeysuckle, including chemical and non-chemical, depending on the extent of the infestation and available time and labor.

Manual and mechanical. For small patches, repeated pulling of entire vines and root systems may be effective. Hand pull seedlings and young plants when the soil is moist, holding low on the stem to remove the whole plant along with its roots.

Monitor frequently and remove any new plants. Cut and remove twining vines to prevent them from girdling and killing shrubs and other plants. An effective method for removal of patches of honeysuckle covering the ground is to lift up and hold a portion of the vine mass with a rake and have a chain saw operator cut the stems low to the ground. Mowing large patches of honeysuckle may be useful if repeated regularly, but is most effective when combined with herbicide application (see below). Mow at least twice a year, first in mid-July and again in mid-September. Plants can also be grubbed out using a Pulaski or similar digging tool, taking care to remove all roots and runners. Burning removes above ground vegetation but does not kill the underground rhizomes, which will continue to sprout. In certain situations, tethered goats have been used to remove honeysuckle growth, but must be monitored to prevent their escape to the wild where they would become an added ecological threat.

Chemical. In moderate cold climates, Japanese honeysuckle leaves continue to photosynthesize long after most other plants have lost their leaves. This allows for application of herbicides when many native species are dormant. However, for effective control with herbicides, healthy green leaves must be present at application time and temperatures must be sufficient for plant activity. Several systemic herbicides (e.g., glyphosate and triclopyr) move through the plant to the roots when applied to the leaves or stems and have been used effectively on Japanese honeysuckle.

Following label guidelines, apply a 2.5% rate of glyphosate (e.g., Rodeo for wetlands; Roundup for uplands) mixed with water and an appropriate surfactant, to foliage from spring through fall. Alternatively, apply a 2% concentration of triclopyr (e.g., Garlon 3A) plus water to foliage, thoroughly wetting the leaves but not to the point of drip-off. A coarse, low-pressure spray should be used. Repeat applications may be needed. Treatment in the fall, when many non-target plants are going dormant, is best. Also, a 25% glyphosate or triclopyr solution mixed with water can be applied to cut stem surfaces any time of year as long as the ground is not frozen.

Biological control. No biological control agents are currently available for Japanese honeysuckle.

SUGGESTED ALTERNATIVE PLANTS: Vines that make good substitutes for Japanese honeysuckle include false jasmine (*Gelsemium sempervirens*), trumpet honeysuckle (*Lonicera sempervirens*), trumpet creeper (*Campsis radicans*), crossvine (*Bignonia capreolata*), native wisteria (*Wisteria frutescens*), jackman clematis (*Clematis jackmanii*), and others. Check with your state native plant society, a reputable native plant nursery, for recommendations for plants that are appropriate for your area and conditions.

USE PESTICIDES WISELY: ALWAYS READ THE ENTIRE PESTICIDE LABEL CAREFULLY, FOLLOW ALL MIXING AND APPLICATION INSTRUCTIONS AND WEAR ALL RECOMMENDED PERSONAL PROTECTIVE GEAR AND CLOTHING. CONTACT YOUR STATE DEPARTMENT OF AGRICULTURE FOR ANY ADDITIONAL PESTICIDE USE REQUIREMENTS, RESTRICTIONS OR RECOMMENDATIONS.

Kudzu *Pueraria montana* var. *lobata* (Willd.) Maesen & S. Almeida

KUDZU

NATIVE RANGE: Asia
DESCRIPTION: Kudzu is a climbing, semi-woody, perennial vine in the pea family. Deciduous leaves are alternate and compound, with three broad leaflets up to 4 inches across. Leaflets may be entire or deeply 2-3 lobed with hairy margins. Individual flowers, about 1/2 inch long, are purple, highly fragrant and borne in long hanging clusters. Flowering occurs in late summer and is soon followed by production of brown, hairy, flattened, seed pods, each of which contains three to ten hard seeds.

ECOLOGICAL THREAT: Kudzu kills or degrades other plants by smothering them under a solid blanket of leaves, by girdling woody stems and tree trunks, and by breaking branches or uprooting entire trees and shrubs through the sheer force of its weight. Once established, Kudzu plants grow rapidly, extending as much as 60 feet per season at a rate of about one foot per day. This vigorous vine may extend 32-100 feet in length, with stems 1/2 - 4 inches in diameter. Kudzu roots are fleshy, with massive tap roots 7 inches or more in diameter, 6 feet or more in length, and weighing as much as 400 pounds. As many as thirty vines may grow from a single root crown.

DISTRIBUTION IN THE UNITED STATES: Kudzu is common throughout most of the southeastern U.S. and has been found as far north as Pennsylvania.

HABITAT IN THE UNITED STATES: Kudzu grows well under a wide range of conditions and in most soil types. Preferred habitats are forest edges, abandoned fields, roadsides, and disturbed areas, where sunlight is abundant. Kudzu grows best where winters are mild, summer temperatures are above 80°F, and annual rainfall is 40 inches or more.

BIOLOGY & SPREAD: The spread of kudzu in the U.S. is currently limited to vegetative expansion by runners and rhizomes and by vines that root at the nodes to form new plants. Kudzu also spreads somewhat through seeds, which are contained in pods, and which mature in the fall. However, only one or two viable seeds are produced per cluster of pods and these hard-coated seeds may not germinate for several years.

BACKGROUND: Kudzu was introduced into the U.S. in 1876 at the Philadelphia Centennial Exposition, where it was promoted as a forage crop and an ornamental plant. From 1935 to the mid-1950s, farmers in the south were encouraged to plant kudzu to reduce soil erosion, and Franklin D. Roosevelt's Civilian Conservation Corps planted it widely for many years. Kudzu was recognized as a pest weed by the U.S. Department of Agriculture and, in 1953, was removed from its list of permissible cover plants.

CURRENT MANAGEMENT APPROACHES: For successful long term control of kudzu, the extensive root system must be destroyed. Any remaining root crowns can lead to reinfestation of an area. Mechanical methods involve cutting vines just above ground level and destroying all cut material.

Close mowing every month for two growing seasons or repeated cultivation may be effective. Cut kudzu can be fed to livestock, burned or enclosed in plastic bags and sent to a landfill. If conducted in the spring, cutting must be repeated as regrowth appears to exhaust the plant's stored carbohydrate reserves.

Late season cutting should be followed up with immediate application of a systemic herbicide (e.g., glyphosate) to cut stems, to encourage transport of the herbicide into the root system. Repeated applications of several soil-active herbicides have been used effectively on large infestations in forestry situations. Efforts are being organized by the U.S. Forest Service to begin a search for biological control agents for kudzu.

SUGGESTED ALTERNATIVE PLANTS: Native vines such as trumpet creeper (*Campsis radicans*), pipevine (*Aristolochia macrophylla*), passionflower (*Passiflora lutea*), trumpet honeysuckle (*Lonicera sempervirens*), and native bittersweet (*Celastrus scandens*) have attractive flowers and fruits, provide food for wildlife and make excellent substitutes for kudzu. These plants should be used in landscaping and for land restoration where they are known to occur as natives.

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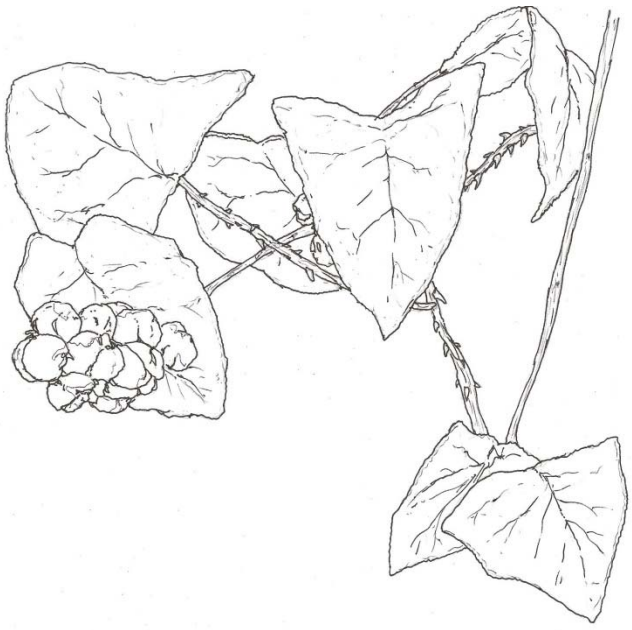
Mile-a-minute weed *Polygonum perfoliatum* L.



MILE A MINUTE WEED

NATIVE RANGE: India to Eastern Asia, China and the Islands from Japan to the Philippines, including Nepal, Burma, Manchuria, China, Korea, Taiwan and the Malay Peninsula

DESCRIPTION: Mile-a-minute weed, also known as Devil's tail tearthumb, is an herbaceous, annual, trailing vine in the buckwheat family, Polygonaceae. It has a reddish stem that is armed with downward pointing hooks or barbs which are also present on the underside of the leaf blades. The light green colored leaves are shaped like an equilateral (equal-sided) triangle and alternate along the narrow, delicate stems. Distinctive circular, cup-shaped leafy structures, called ocreas, surround the stem at intervals. Flower buds, and later flowers and fruits, emerge from within the ocreas. Flowers are small, white and generally inconspicuous. The fruits are attractive, metallic blue and segmented, each segment containing a single glossy, black or reddish-black seed.

ECOLOGICAL THREAT: Mile-a-minute weed grows rapidly, scrambling over shrubs and other vegetation, blocking the foliage of covered plants from available light, and reducing their ability to photosynthesize, which stresses and weakens them. If left unchecked, the lack of photosynthesis will kill a plant. Large infestations of mile-a-minute weed eventually reduce native plant species in natural areas. Small populations of extremely rare plants may be eliminated entirely. Because it can smother tree seedlings, mile-a-minute weed has a negative effect on Christmas tree farms, forestry operations on pine plantations and reforestation of natural areas. It has the potential to be a problem to nursery and horticulture crops that are not regularly tilled as a cultivation practice.

DISTRIBUTION IN THE UNITED STATES: Mile-a-minute weed is currently found in Pennsylvania, Maryland, Delaware, West Virginia, New York, Virginia, Ohio and Washington, D.C. These states and the District of Columbia comprise about 20 percent of the estimated possible range for this species. It is considered a temperate species with subtropical tendencies and therefore has the potential to invade those portions of the contiguous United States that have the appropriate climate to provide a minimal eight week cold vernalization period. A temperature of 10°C or below must be sustained for an eight week period to stimulate germination.

HABITAT IN THE UNITED STATES: Mile-a-minute weed generally colonizes open and disturbed areas, along the edges of woods, wetlands, stream banks, and roadsides, and uncultivated open fields, resulting from both natural and human causes. Natural areas such as stream banks, parks, open space, road shoulders, forest edges and fence lines are all typical areas to find mile-a-minute. It also occurs in environments that are extremely wet with poor soil structure. Available light and soil moisture are both integral to the successful colonization of this species. It will tolerate shade for part of the day, but needs a good percentage (63-100%) of available light. The ability of mile-a-minute to attach to other plants with its recurved barbs and climb over the plants to reach an area of high light intensity is a key to its survival. It can survive in areas with relatively low soil moisture, but demonstrates a preference for high soil moisture.

BACKGROUND: The first records of mile-a-minute in North America are from Portland, Oregon (1890) and Beltsville, Maryland (1937). Both of these sites were eliminated or did not establish permanent populations of the species. However, the introduction of mile-a-minute in the late 1930's to a nursery site in York County, Pennsylvania did produce a successful population of this plant. It is speculated that the seed was spread with Rhododendron stock. The owner of the nursery was interested in the plant and allowed it to reproduce; unfortunately, subsequent efforts to eradicate it were not successful.

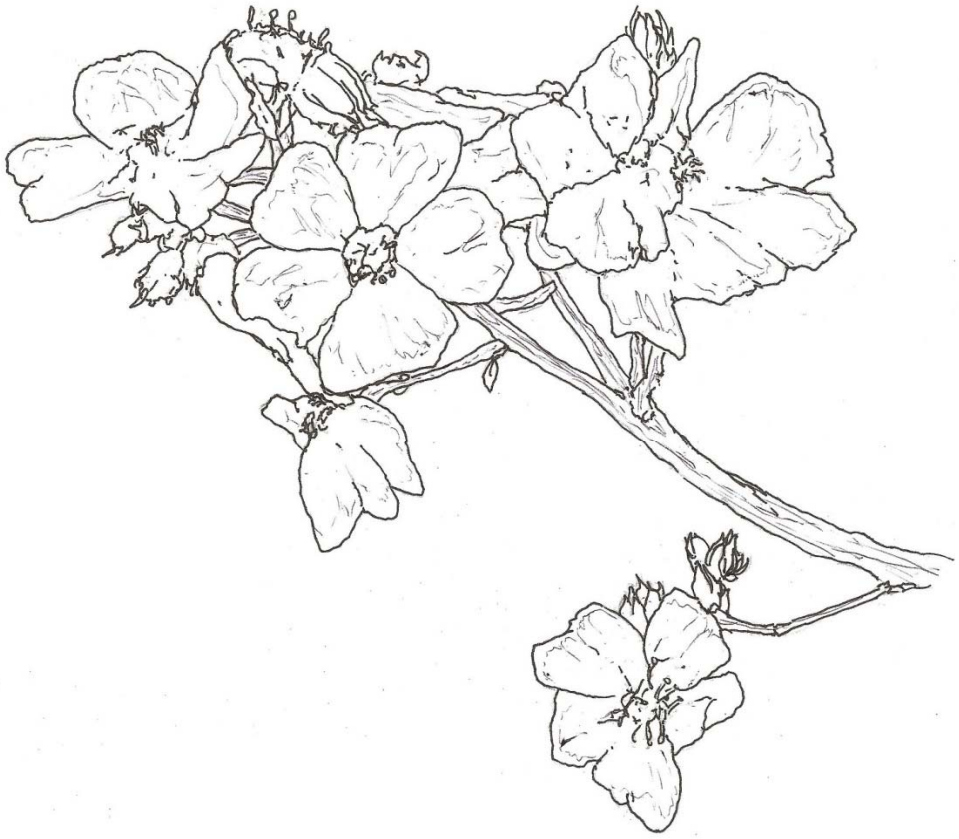
The distribution of mile-a-minute has radiated from the York County site into neighboring states. In the past 55 years, the range for this plant in the United States has extended as far as 300 miles in several directions from the York County, Pennsylvania site (Mountain, 1995) and (Okay 1997).

BIOLOGY & SPREAD: Mile-a-minute weed is primarily a self-pollinating plant (supported by its inconspicuous, closed flowers and lack of a detectable scent), with occasional outcrossing. Fruits and viable seeds are produced without assistance from pollinators. Vegetative propagation from roots has not been successful for this plant. It is a very tender annual, withering with a slight frost, and reproduces successfully until the first frost. Mile-a-minute is a prolific seeder, producing many seeds on a single plant over a long season, from June until October in Virginia, and a slightly shorter season in more northern geographic areas.

Birds are probably the primary long-distance dispersal agents of mile-a-minute seeds. Transport of seeds short distances by native ant species has been observed. This activity is probably encouraged by the presence of a tiny white food body (elaiosome) on the tip of the seed that may be attractive to the ants. These seed-carrying ants may play an important role in the survival and germination of the seeds of mile-a-minute weed. Local bird populations are important for dispersal under utility lines, bird feeders, fence lines and other perching locations. Other animals observed eating mile-a-minute weed fruits are chipmunks, squirrel and deer.
Water is also an important mode of dispersal for mile-a-minute weed. Its fruits can remain buoyant for 7-9 days, an important advantage for dispersing seed long distances in stream and river environments. The long vines frequently hang over waterways, allowing fruits that detach to be carried away in the water current. During storm events the potential spread of this plant is greatly increased throughout watersheds.

CURRENT MANAGEMENT APPROACHES: A variety of control measures, including physical, mechanical, cultural and chemical, can be used for management of mile-a-minute weeds. Hand pulling of seedlings is best done before the recurved barbs on the stem and leaves harden. But may be done afterwards with the help of thick gloves. Removal of vines by hand may be conducted throughout the summer, if tough gloves and protective clothing (coveralls) are worn to avoid the skin shredding ability of the recurved hooks. The delicate vines can be reeled in fairly easily and balled up in piles that can be left to dehydrate for several days before disposal. The site must be rechecked at frequent intervals, and removal of new plants continued until the seed germination period is complete, roughly early April until early July in the Middle Atlantic States. Repeated mowing or trimming of mile-a-minute plants will prevent the plants from flowering and thus reduce or eliminate fruit and seed production.

Multiflora Rose



MULTIFLORA ROSE

Description
Multiflora rose is a medium height, thorny, bushy shrub with a more spreading then erect growth form. Leaves are born alternately on the stems and divided into 5-11 leaflets (usually 7-9). Each leaflet is broadly oval and toothed along its margin. Clusters of numerous, white flowers, 3/4" - 1-1/2 inches (1.9-3.8 cm) across, blossom in late spring. The fruits are small, firm, red hips that may remain on the plant well into winter. Older rose shrubs may obtain a height of 15 feet (4.6 meters) or more with a root crown diameter of 8 inches (20 cm).

Similar Species
Multiflora rose can be distinguished from native roses by the presence of a feathery or comb-like margin on the narrow stipules (a green, leaf-like structure) found at the base of each leaf stalk. Illinois' native rose species all have stipules at the base of the leaf stalk, but stipules of the native roses do not have feathery margins. Also, the styles (floral structures) of multiflora rose are fused together into a column, while all native roses except for prairie rose (Rosa setigera) have separate styles. Multiflora rose should be accurately identified before attempting any control measures. If identification of the species is in doubt, the plant's identity should be confirmed by a knowledgeable individual and/or by consulting appropriate books.

Distribution
Multiflora rose was introduced into Illinois in the 1950's from eastern Asia for wildlife cover and food. Managers recognized that plantings of this thorny, bushy shrub provided excellent escape cover and a source of winter food.

Because of its dense thorny nature, the commercial nursery trade began marketing it as a "living fence" as well. The species soon spread and became a serious invader of agricultural lands, pastures, and natural communities.

Habitat
Multiflora rose occurs in successional fields, pastures, and roadsides. It also may occur in dense forests, particularly near disturbances such as treefall gaps.

Life History
Multiflora rose is named for the clusters of many white flowers born on this perennial bramble during May or June. The flowers develop into small, hard fruits called hips that remain on the plant throughout winter. The great majority of plants develop from seeds remaining in the soil relatively close to plants from which they were produced. Birds and mammals also consume the hips and can disperse them greater distances. Rose seeds may remain viable in the soil for 10-20 years. Multiflora rose also spreads by layering, i.e., where tips of canes touch the ground and form roots, and by plants that arise from shallow roots.

Effects Upon Natural Areas
Multiflora rose readily invades prairies, savannas, open woodland, and forest edges. It is a thorny, bushy shrub that can form impenetrable thickets or "living fences" and smother out other vegetation. It is a serious pest species throughout the eastern United States.

CONTROL RECOMMENDATIONS
RECOMMENDED PRACTICES IN NATURAL COMMUNITIES OF HIGH QUALITY
Pulling, grubbing, or removing individual plants from the soil only can be effective when all roots are removed or when plants that develop subsequently from severed roots are destroyed. These approaches are most practical for light, scattered infestations.

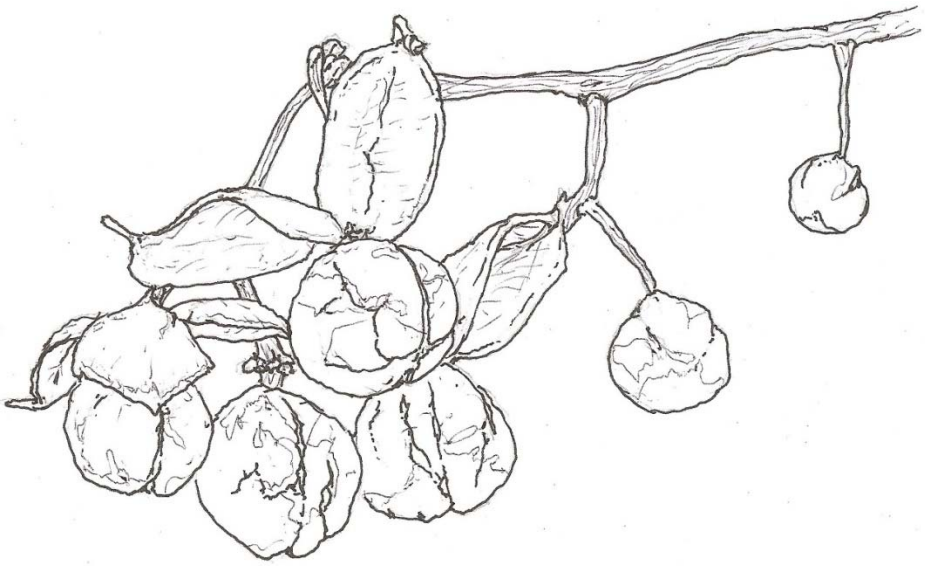
In fire-adapted communities, a routine prescribed burn program will hinder invasion and establishment of multiflora rose.

Research indicates that 3-6 cuttings or mowings per growing season for more than one year can achieve high plant mortality. Such treatment may need to be repeated for 2-4 years. Increased mowing rates (+6/season) did not increase plant mortality. In high quality communities, repeated cutting is preferred over mowing, because repeated mowing will damage native vegetation as well as multiflora rose.

Cutting stems and either painting herbicide on the stump with a sponge applicator (sponge-type paint applicators can be used) or spraying herbicide on the stump with a low pressure hand-held sprayer kills root systems and prevents resprouting. Roundup herbicide (a formulation of glyphosate) has been effective in controlling multiflora rose when used as a 10-20% solution and applied directly to the cut stump. Although the Roundup label recommends a higher concentration for cut-stump treatment (50-100%), this lower concentration has proven effective. With this technique, herbicide is applied specifically to the target plant, reducing the possibilities of damaging nearby, desirable vegetation.

Cut-stump treatment is effective late in the growing season (July-September), and also during the dormant season. Dormant season application is preferred because it will minimize potential harm to nontarget species. Glyphosate is a nonselective herbicide, so care should be taken to avoid contacting nontarget species. In addition, Triclopyr (tradename Garlon 3A) can be applied to cut stems or canes for selective control of multiflora rose. Garlon 3A diluted in water at a rate of 50% can be sprayed, using a hand sprayer, to the cut surface. Application should be within a few hours of cutting. Use of Garlon 3A is best done in the dormant season to lessen damage to nontarget species. Great care should be exercised to avoid getting any of the herbicide on the ground near the target plant since some nontarget pecies may be harmed. Avoid using Triclopyr if rain is forecast for the following 1-4 days; otherwise runoff will harm nontarget species. By law, herbicides only may be applied according to label directions and by licensed herbicide applicators or operators when working on public properties.

Oriental Bittersweet *Celastrus orbiculatus* Thunb.



ORIENTAL BITTERSWEET

NATIVE RANGE: Eastern Asia, Korea, China and Japan

DESCRIPTION: Oriental bittersweet is a deciduous, woody, perennial vine in the staff-tree family (Celastraceae), which sometimes occurs as a trailing shrub. Also known as round-leaved and Asiatic bittersweet, stems of older plants sometimes grow to four inches in diameter. Leaves of oriental bittersweet are glossy, rounded, finely toothed and arranged alternately along the stem. Clusters of small greenish flowers emerge from leaf axils, allowing each plant to produce large numbers of seeds. At maturity, globular, green to yellow fruits split open to reveal three red-orange, fleshy arils that contain the seeds. These showy fruits have made oriental bittersweet very popular for use in floral arrangements. Since this plant is easily confused with our native climbing bittersweet vine (*Celastrus scandens*), which flowers at the tips rather than along the stems, it is imperative that correct identification be made before controls are attempted.

ECOLOGICAL THREAT: Oriental bittersweet is an aggressive invader that threatens all vegetation levels of forested and open areas. It grows over other vegetation, completely covering it, and kills other plants by preventing photosynthesis, girdling, and uprooting by force of its massive weight. In the northeastern U.S., exotic Oriental bittersweet appears to be displacing the native climbing bittersweet (*Celastrus scandens)*, which occurs in similar habitats, through competition and hybridization.

DISTRIBUTION IN THE UNITED STATES: Oriental bittersweet currently occurs from New York to North Carolina, and westward to Illinois.

HABITAT IN THE UNITED STATES: Oriental bittersweet infests forest edges, woodlands, early successional fields, hedgerows, coastal areas and salt marsh edges, particularly those suffering some form of land disturbance. While often found in more open, sunny sites, its tolerance for shade allows oriental bittersweet to invade forested areas.

BACKGROUND: Introduced into the U.S. in the 1860s as an ornamental plant, oriental bittersweet is often associated with old home sites, from which it has escaped into surrounding natural areas. Oriental bittersweet is still widely planted and maintained as an ornamental vine, further promoting its spread.
BIOLOGY & SPREAD: Oriental bittersweet reproduces prolifically by seed, which is readily dispersed to new areas by many species of birds. Its seeds germinate in late spring in partial to dense shade. It

also expands vegetatively by stolons (above-ground stems), and rhizomes (underground stems), and through root suckering (the ability to send shoots up from the roots).

CURRENT MANAGEMENT APPROACHES: Where hand labor is practical, vines can be pulled out by the roots and removed from the site, preferably before fruiting. If fruits are present, vines should be bagged and disposed of in a landfill, or left in the bags and allowed to bake in the sun long enough to kill the seeds. Certain systemic herbicides, such as glyphosate (e.g., Roundup) or triclopyr (e.g., Garlon), that are taken into the roots and kill the entire plant, have been used successfully in bittersweet management. This method is most effective if the stems are first cut by hand or mowed and herbicide is applied immediately to cut stem tissue. In areas where spring wildflowers or other native plants occur, application of herbicides should be conducted prior to their emergence, delayed until late summer or autumn, after the last killing frost occurs, or carefully targeted. Herbicidal contact with desirable plants should always be avoided. No biological controls are currently known for oriental bittersweet.

SUGGESTED ALTERNATIVE PLANTS: Several attractive native vines are available that provide nectar, seed, and host plant material for butterflies, hummingbirds, and other wildlife. These include common, or climbing, bittersweet (*Celastrus scandens*) which is native to the eastern U.S., trumpet creeper (*Campsis radicans*), passionflower vine (*Passiflora lutea*), pipevine or Dutchman's pipe (*Aristolochia macrophylla*) and native wisteria* (*Wisteria frutescens*).

*If you wish to plant wisteria, make certain that it is the native species. Two commonly planted ornamental wisterias; Chinese wisteria *(Wisteria sinensis)* and Japanese wisteria *(Wisteria floribunda)*, are exotic and aggressive invaders.

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Porcelainberry *Ampelopsis brevipedunculata* (Maxim.) Trautv.

NATIVE RANGE: China, Korea, Japan, Russian Far East
DESCRIPTION: Porcelainberry is a deciduous, woody, perennial vine of the grape family, Vitaceae. It is related to the North American raccoon-grape and peppervine, and is sometimes referred to as Amur peppervine or porcelain ampelopsis. The simple, heart-shaped leaves of porcelainberry are dark green with coarsely toothed edges, and are shiny underneath with delicate hairs along the veins. The leaves vary from slightly 3-5 lobed to deeply dissected, the latter being distinctively recognizable. The leaves are arranged alternately on vines that grow to heights of 15 to 20 feet. The plant climbs by tendrils that grow opposite the leaves on the stem. Small, greenish-white flowers appear in clusters on porcelainberry in June, July, and August. The colorful berries of porcelainberry, its most distinguishing feature, appear in September-October. The berries, about 1/4-inch in diameter, range in color from white to yellow, to pastel shades of green, lilac and amethyst purple, to turquoise and sky blue. All colors of the berry are often found growing on the same plant at the same time while the plant is still in full foliage. There are several US native species of Ampelopsis that could be confused with this exotic.

ECOLOGICAL THREAT: Porcelainberry is a vigorous vine which is slow to establish but grows and spreads quickly in open areas of the urban landscape. The seeds of porcelainberry are similar in size to those of native pioneers, and like the native, they will germinate readily in the prepared soil bed left behind after natural or human disturbance. Once established, the vine quickly overwhelms and destroys native vegetation by shading out smaller plants and outcompeting native vegetation for water and nutrients. Urban parks, with extensive wooded borders neighboring landscaped residential and private property, are especially vulnerable to invasion by porcelainberry.

DISTRIBUTION IN THE UNITED STATES: New England to North Carolina and west to Michigan.

HABITAT IN THE UNITED STATES: Porcelainberry grows well in most soils, especially in pond margins, streambanks, thickets, and waste places, where there is full sunlight to partial shade, and where it is not permanently wet. Like its relative the grape, porcelainberry appears to be less tolerant of heavily shaded areas, such as that found in mature forest.

BACKGROUND: Porcelainberry was originally cultivated as a bedding and landscape plant. In spite of its aggressiveness in some areas, it is still used in the horticultural trade (for example, the ornamental *A. brevipedunculata* 'Elegans' is often recommended as a landscape plant with a cautionary note that "care must be taken to keep it from overtaking and shading out small plants").

The characteristics that make porcelainberry a desirable plant for the garden -- its colorful berries, good ground coverage, trellis-climbing vines, pest-resistance, and tolerance of adverse conditions -- are also responsible for its presence in the United States as an undesirable invader.

BIOLOGY & SPREAD: The colorful berries (carrying 2-4 seeds each) attract birds and other small animals that eat the berries and disperse the seeds in their droppings. Because the plant is often found growing in riparian areas downstream from established plant colonies, it is thought that the seeds may also be dispersed in stream water.

CURRENT MANAGEMENT APPROACHES: Since the vines can grow as long as 15 ft. in a single growing season, repeated applications in the same growing season and in subsequent years may be necessary to fully eradicate the plant.

Manual. Because flowers are produced on the current season's growth, hand-pruning in the fall or spring will prevent flower buds from forming the following season. Where feasible, plants should be pulled up by hand before fruiting to prevent the spread of seeds. If the plants are pulled while in fruit, the fruits should be bagged and burned before they ripen. This method can be difficult in areas where the plant is well established since pulling up the plant often pulls out native plants with intermingled roots. Cut aboveground vines and, if possible, pull from trees to allow the trees to recover and re-cut repeatedly as needed.

Chemical. The herbicides triclopyr (e.g., Garlon 3a and Garlon 4) and glyphosate (Roundup and Rodeo) have been used with varying success to battle infestations of porcelainberry.

Foliar applications: Smaller infestations of porcelainberry can be controlled to some extent with spot applications of glyphosphate to leaves, used sparingly to avoid contact of desirable plants with spray. Cut vines back during the summer and allow to resprout before applying herbicide, or apply glyphosate to leaves in early autumn, just prior to senescence. More effective control has been achieved using triclopyr formulations. From summer to fall, apply a water-based solution of 2.5% Garlon 3A (triclopyr amine) to foliage or cut first, allow to re-grow, and then apply triclopyr to new growth.

Basal bark applications*:* Apply a mixture of 20-30% Garlon 4 (triclopyr ester) with an equal volume of commercially available basal oil, diesel fuel, No. 1 or 2 fuel oil, or kerosene. Other oils, such as horticultural oil, can be substituted if the label for the oil recommends it for basal bark application. Application should be during any season when temperatures are around 60°F or more for several days; apply around the basal portions of vines.

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Topic 5 Vine Section Alien Plant Invaders
Answers at the rear of Glossary

Fill-in-the-blank

1. Small infestations of fiveleaf akebia can be controlled mechanically. Because of its extremely rapid growth, cutting will need to be repeated throughout the season. At a minimum, _____should be cut back to the ground at the end of the summer.

2. _____is a vigorous vine which is slow to establish but grows and spreads quickly in open areas of the urban landscape. The seeds of porcelainberry are similar in size to those of native pioneers, and like the native, they will germinate readily in the prepared soil bed left behind after natural or human disturbance.

3. _____is a deciduous, woody, perennial vine in the staff-tree family (Celastraceae), which sometimes occurs as a trailing shrub. Also known as round-leaved and Asiatic bittersweet, stems of older plants sometimes grow to four inches in diameter.

4. A variety of mechanical and chemical methods are available for management of_____. Grubbing, a rather labor intensive method, is effective for small populations or environmentally sensitive areas where herbicides cannot be used.

5. _____is an aggressive invader that threatens all vegetation levels of forested and open areas, growing along the ground as well as into the forest canopy. The dense growth and abundant leaves, which spring from the stems like small umbrellas, form a thick canopy just above the ground, and prevent sunlight from reaching other plants.

6. _____is a popular plant, recommended by Cooperative Extension offices for use as a low maintenance alternative to lawns. It is widely used by homeowners, horticulturists, landscape contractors, parks departments and others desiring a fast-growing, low maintenance, evergreen groundcover.

7. In moderate cold climates, _____leaves continue to photosynthesize long after most other plants have lost their leaves. This allows for application of herbicides when many native species are dormant.

8. Birds are probably the primary long-distance dispersal agents of _____seeds. Transport of seeds short distances by native ant species has been observed. This activity is probably encouraged by the presence of a tiny white food body (elaiosome) on the tip of the seed that may be attractive to the ants.

9. For successful long term control of_____, the extensive root system must be destroyed. Any remaining root crowns can lead to reinfestation of an area. Mechanical methods involve cutting vines just above ground level and destroying all cut material.

10. _____ is a perennial and can be found growing in waste places, fields, and along roadsides. It is a low growing vine that can reach a length of 20 feet. The large, yellow flowers open in the mornings and are 3 to 4 inches long and 1 to 2 inches wide. The gray-green leaves are a narrow triangle shape that tend to fold upward, parallel to the midvein. The fruit is a gourd that is dark green with lighter green stripes when immature. It is about 2 to 3 inches in diameter at maturity and turns a yellow color.

Topic 6 Tree Section- Alien Plant Invaders

Australian Pine *Casuarina equisetifolia* L.

NATIVE RANGE: Malaysia, southern Asia, Oceania and Australia
DESCRIPTION: A member of the beefwood family (Casuarinaceae), Australian pine is a deciduous tree with a soft, wispy, pine-like appearance that can grow to 100 feet or more in height. Also known as ironwood, beefwood, she oak and horsetail tree, it bears a superficial resemblance to the conifer genus *Pinus* because of its small, round, cone-like fruits and its branchlets of scale-like leaves that look like pine needles. Its flowers are tiny, brown and wind-pollinated. The fruit is a nutlet about ½ inch in diameter that contains winged seeds.

ECOLOGICAL THREAT: Australian pine is fast-growing (5-10 feet per year), produces dense shade and a thick blanket of leaves and hard, pointed fruits that completely cover the ground beneath it. Dense thickets of Australian pine displace native dune and beach vegetation, including mangroves and many other resident, beach-adapted species. Because its roots are capable of producing nitrogen through microbial associations, Australian pine can colonize nutrient-poor soils. Once established, it radically alters the light, temperature, and soil chemistry regimes of beach habitats, as it outcompetes and displaces native plant species and destroys habitat for native insects and other wildlife. Chemicals in the leaves of Australian pine may inhibit the growth of other plants underneath it.
The ground below Australian pine trees becomes ecologically sterile and lacking in food value for native wildlife. Unlike native shrubbery, the thick, shallow roots of Australian pine make it much more susceptible to blow-over during high wind events, leading to increased beach and dune erosion and interference with the nesting activities of sea turtles.
DISTRIBUTION IN THE UNITED STATES: Australian pine is established in the Hawaiian islands, coastal Florida, Puerto Rico, the Bahamas, and many Caribbean islands.
HABITAT IN THE UNITED STATES: Australian pine occurs in open, coastal strand habitat, characterized by sand and shell beaches, rocky coasts, sand dunes, and sand bars in subtropical climates.
BIOLOGY & SPREAD: Australian pine is capable of flowering year-round and can produce tremendous numbers of small, winged seeds which are dispersed by wind.
BACKGROUND: Australian pine was introduced to Florida in the late 1800's and planted widely for the purposes of ditch and canal stabilization, shade and lumber.
CURRENT MANAGEMENT APPROACHES: No biological controls are currently available for management of Australian pine. For new or small infestations, manual removal of Australian pine seedlings and saplings is recommended. For heavier infestations, application of a systemic type herbicide to bark, cut stumps, or foliage is likely to be the most effective management tool. Prescribed fire has also been used for large infestations in fire-tolerant communities.
Raking and removal of leaf litter, cones and seeds should be done whenever possible. Impacts to native plants should be minimized during any control activities. Whenever possible, efforts should be taken to prevent the introduction or encroachment of Australian pine. For example, recently disturbed beach habitat may be planted with native vegetation to prevent Australian pine from invading.

USE PESTICIDES WISELY: ALWAYS READ THE ENTIRE PESTICIDE LABEL CAREFULLY, FOLLOW ALL MIXING AND APPLICATION INSTRUCTIONS AND WEAR ALL RECOMMENDED PERSONAL PROTECTIVE GEAR AND CLOTHING. CONTACT YOUR STATE DEPARTMENT OF AGRICULTURE FOR ANY ADDITIONAL PESTICIDE USE REQUIREMENTS, RESTRICTIONS OR RECOMMENDATIONS.

Brazillian Peppertree *Schinus terebinthifolius*

BRAZILLIAN PEPPERTREE

Schinus terebinthifolius is a species of flowering plant in the cashew family, Anacardiaceae, that is native to subtropical and tropical South America (southeastern Brazil, northern Argentina and Paraguay). It is found in the following states of Brazil: Alagoas, Bahia, Espírito Santo, Mato Grosso do Sul, Minas Gerais, Pernambuco, Paraná, Rio de Janeiro, Rio Grande do Norte, Rio Grande do Sul, Santa Catarina, São Paulo and Sergipe. Common names include **Brazilian pepper**, **aroeira**, **rose pepper**, and **Christmasberry**.

Brazilian pepper is a sprawling shrub or small tree, with a shallow root system, reaching a height of 7–10 m. The branches can be upright, reclining, or nearly vine-like, all on the same plant. Its plastic morphology allows it to thrive in all kinds of ecosystems: from dunes to swamps, where it grows as a quasi-aquatic plant. The leaves are alternate, 10–22 cm long, pinnately compound with (3–) 5–15 leaflets; the leaflets are roughly oval (lanceolate to elliptical), 3–6 cm long and 2–3.5 cm broad, and have finely toothed margins, an acute to rounded apex and yellowish veins.

The leaf rachis between the leaflets is usually (but not invariably) slightly winged. The plant is dioecious, with small white flowers borne profusely in axillary clusters. The fruit is a small red spherical drupe 4–5 mm diameter, carried in dense clusters of hundreds of berries.

There are two varieties:

- *S. terebinthifolius* var. *acutifolius*. Leaves to 22 cm, with 7–15 leaflets; fruit pink.
- *S. terebinthifolius* var. *terebinthifolius*. Leaves to 17 cm, with 5–13 leaflets; fruit red.

Carrotwood *Cupaniopsis anacardioides* (A. Rich.) Radlkf.

NATIVE RANGE: Australia, Iran Jaya (Indonesia) and Papua New Guinea
DESCRIPTION: Carrotwood is a fast-growing evergreen tree in the Soapberry family (Sapindaceae) that grows to a height of about 35 feet. The leaves are large and compound, made up of four to ten oblong leaflets, each 4 to 8 inches long, and attached by a swollen stalk. Leaflet edges tend to be wavy with rounded tips that are often indented. Leaves alternate along the stems. In Florida, flowering occurs in the winter, from January to March. Clusters of small, greenish-white flowers are borne on stalks that emerge from leaf axils. Flowers are unisexual, with each flower cluster containing both male and female flowers. The brightly colored fruit is a yellow, three-lobed capsule which, when ripe (May to June) splits open to expose three shiny black seeds encased in red or orange fleshy tissue.
ECOLOGICAL THREAT: While carrotwood invades a variety of natural communities, including dunes, coastal strand, sand pine scrub, slash pine flatwoods, cypress swamps, freshwater marshes and river banks, it poses a special threat to coastal ecosystems like mangrove swamps and tropical hammocks. Coastal plant communities provide crucial erosion control, water quality benefits, and food and shelter for wildlife. Once introduced, carrotwood forms dense monocultures, crowding out and out-competing native plants for available light and nutrients.
Because mangroves provide critical habitat for wading and diving birds, some of which are designated Species of Special Concern, and serve as nursery grounds for crabs, other crustaceans, invertebrates and commercial and recreational fish, the impacts of carrotwood establishment are serious and far-reaching. Coastal hammocks and mangroves are continually losing ground to development and are also impacted by natural forces such as tropical storms and hurricanes. Alteration of species composition and competition by invasive exotic species increases stress to the remaining hammocks. Because carrotwood is a popular, fast-growing landscape tree that is widely planted and very adaptable, the impacts to mangroves and other habitats are expected to increase. Carrotwood has also been found growing among other aggressive, invasive exotic trees.
DISTRIBUTION IN THE UNITED STATES: As of 1996, carrotwood has been documented to occur in natural areas in fourteen Florida counties, from Brevard and Hillsborough counties southward. The current distribution of carrotwood parallels that of mangrove tree species. While naturalized carrotwood infestations are limited primarily to coastal areas, inland populations are beginning to surface. Carrotwood has also been used ornamentally in California, but there are no reports of naturalized populations there, perhaps due to their drier climate. Cold tolerance may limit its potential distribution. According to one reference, carrotwood is able to withstand temperatures to about 22 F (-6 C). Test specimens in northern Florida, however, have withstood winters at least that cold.
HABITAT IN THE UNITED STATES: Tolerant of salt, poor soils, poor drainage, sunlight and shade, carrotwood can adapt to dry areas, and appears in disturbed and undisturbed sites. As a result, carrotwood inhabits a variety of habitats including coastal hammocks, dunes, coastal strand, sand pine scrub, slash pine flatwoods, mangrove swamps, cypress swamps, freshwater marshes and river banks.
BACKGROUND: University of Florida Herbarium specimens document carrotwood cultivation as early as 1955 in eastern Florida. A separate introduction in Sarasota, Florida in 1968 resulted in large scale propagation and use as an ornamental tree.
Carrotwood became a popular landscape tree throughout southern Florida in the late 1970s and early 1980s. By 1990, wild carrotwood seedlings began to be seen in the wild in various habitats.
BIOLOGY & SPREAD: Carrotwood is a prolific seed producer, and the brightly colored fruits are very attractive to birds which disperse it widely. Bird dispersal explains isolated island populations and

seedlings under trees and telephone poles. Seedlings have also been found along estuary rack lines. Clumps of seedlings suggest dispersal by small mammals. In its native range, carrotwood is pollinated by bees, which are the likely pollinators in Florida.

CURRENT MANAGEMENT APPROACHES: No biological control is available at this time. Chemical control is the most common and effective method of control. Triclopyr (e.g., Garlon) has proved effective as a basal bark treatment and cut stump treatment. Glyphosate (e.g., Rodeo) is marginally successful, and usually requires retreatment. Care must be taken in mangrove and wetland areas to avoid impacts to sensitive flora and fauna by use of chemicals or heavy equipment. As a preventive measure, a few counties and municipalities have ordinances restricting use of carrotwood.

SUGGESTED ALTERNATIVE PLANTS: Many native trees make good landscape substitutes for carrotwood. In southern Florida, alternatives include paradise tree (*Simarouba glauca*), pigeon plum (*Coccoloba diversifolia*), Jamaican dogwood (*Piscidia piscipula*), and inkwood (*Exothea paniculata*). In northern and central Florida, there's loblolly bay (*Gordonia lasianthus*), laurel cherry (*Prunus carolinana*) and magnolias (*Magnolia virginiana* or *M. grandiflora*). Dahoon holly (*Ilex casseine*) has a broad range and colorful red fruit.

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Castor Bean *Ricinus communis*

Family: Euphorbiaceae (spurge family)
Common Names: castor bean, castor oil plant, palma Christi, wonder tree
Description
In frost-free areas, castor bean is an evergreen herbaceous or semi woody large shrub or small tree that gets up to 40 ft (12 m) tall and 15ft (4.6 m) wide. In the tropics, it can have a trunk that is woody near the base and up to a foot in diameter. Elsewhere, castor bean plant grows as an annual that can get 8-15 ft (2.4-4.6 m) tall in a single growing season. This is a fast growing, suckering, and colony forming plant with decidedly tropical looking foliage. They tend to grow straight up at first, developing branches only later in the season (and in subsequent years for plants that live that long). The huge leaves are palmate, with 5-11 deeply incised lobes. They are glossy purplish or reddish-green and 12-30 in (30-76 cm) across, with long petioles (leaf stems). The stems are watery juicy and reddish or purplish too.

The inflorescence is not particularly showy; small, 0.5 in (1 cm) wide greenish yellow flowers are borne in fat spikes 8-18" tall near the tops of the stems. Female flowers are on the top half of the spike and have conspicuous red stigmas (the parts that receive the pollen). The male flowers on the lower half of the spike have conspicuous yellow anthers (the parts that give off the pollen). The female flowers are followed by reddish brown egg-shaped capsules, about an inch long, thickly covered with soft flexible spines. Each capsule contains three seeds that look like fat swollen dog ticks and are deadly poisonous.

There are several named cultivars, including some grown commercially for oil production, and this sampling of ornamentals: 'Carmencita' has bronzy red leaves and bright red female flowers. 'Impala' is small, 4-5 ft (1.2-1.5 m) tall and has red leaves that age to reddish purple.

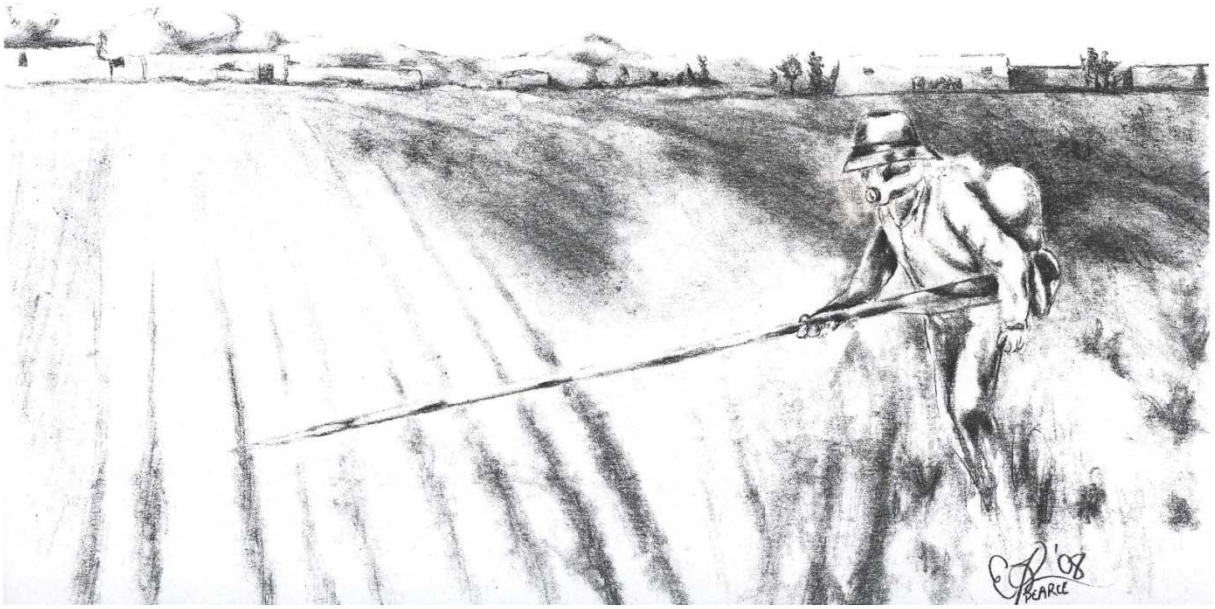
'Sanguineus' has blood-red stems and leaves. 'Gibsonii Mirabilis' is dwarf, only 4' tall, and has dark red leaves and stems. 'Zanzibarensis' is taller and has larger leaves that are green with white veins.

Location
Castor bean was originally native to northeastern Africa and the Middle East. It has escaped cultivation and become naturalized as a weed almost everywhere in the world that has a tropical or subtropical climate. Castor bean grows wild on rocky hillsides, and in waste places, fallow fields, along road shoulders and at the edges of cultivated lands.

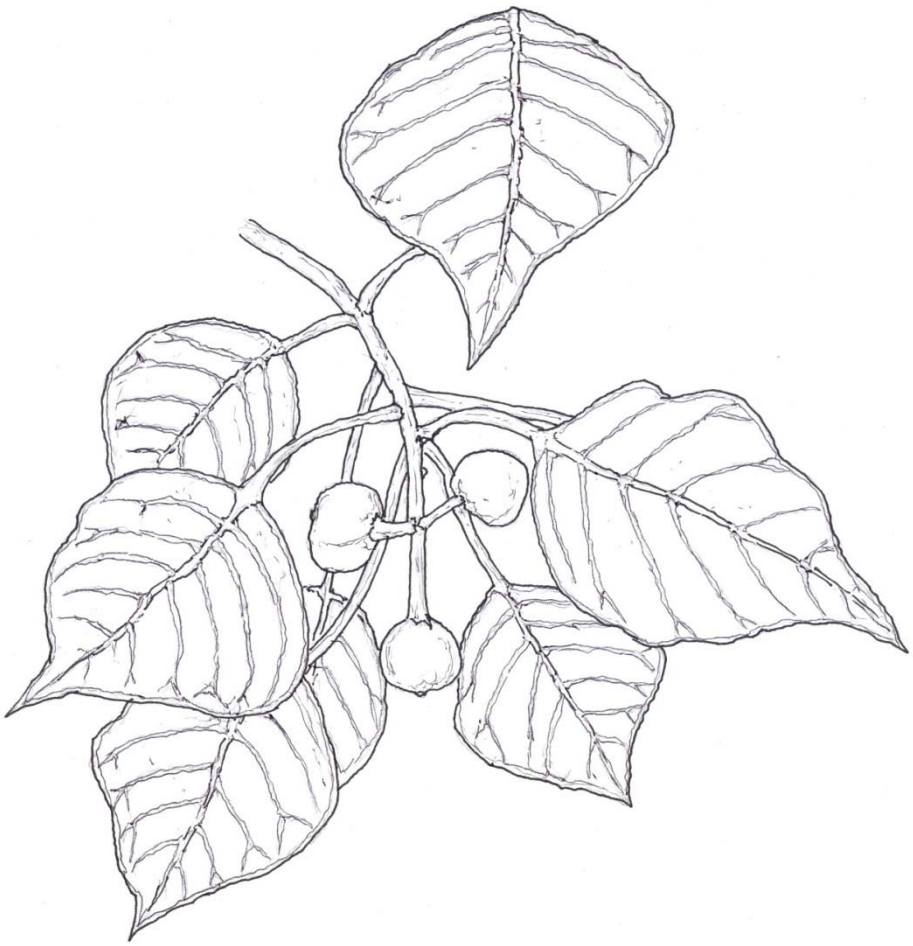
The problem
Castor oil plant spreads over sandy soil areas, creekbanks, and gullies. This can lead to a significant loss of prime grazing land. The seeds of castor oil contain ricin, a poison which is extremely toxic to livestock and humans. Leaves have a lesser amount of toxin. Symptoms of poisoning in animals usually do not appear for a few hours or several days.

Seeds cause gastro-intestinal disorders; leaves tend to cause neuro-muscular disorders. Poisoning in livestock is rarely reported though, as castor oil plant is seldom grazed by stock when other pasture plants are available. Also, small amounts of the plant will induce immunity to poisoning.

Control
Individual plants or small infestations may be removed by cultivation or hand-pulling. Broad-scale infestations may require spraying with herbicides to control the plant.



Chinese Tallow *Triadica sebifera*



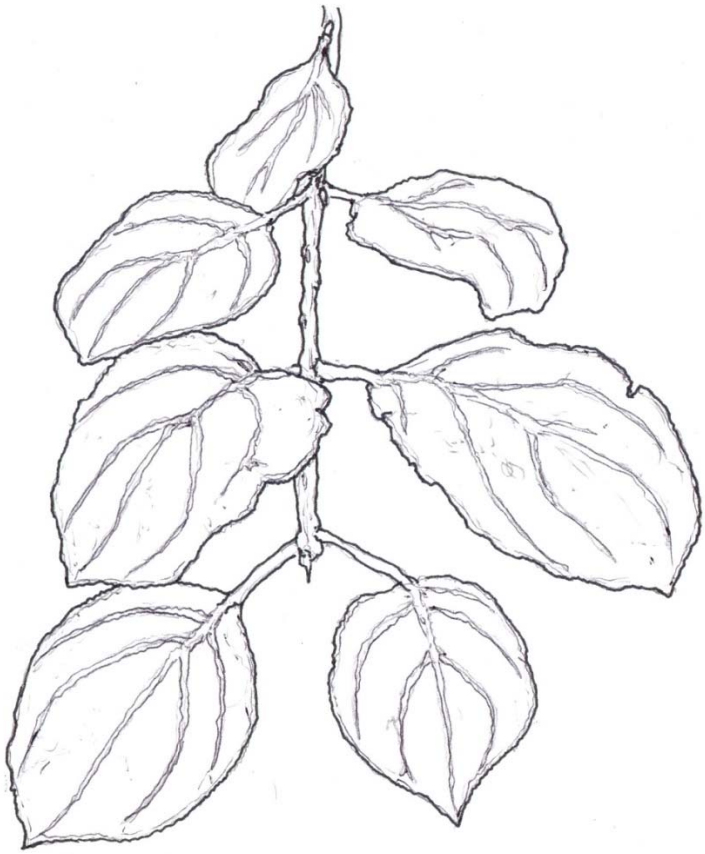
CHINESE TALLOW

Triadica sebifera, also known as ***Sapium sebiferum***, is commonly known as the **Chinese tallow tree**, **Florida aspen**, **chicken tree**, **gray popcorn tree**, and **candleberry tree**. The tree is native to eastern Asia, and is most commonly associated with eastern China, Taiwan, and Japan. In these regions, the waxy coating of the seeds is used for candle and soap making, and the leaves are used as herbal medicine to treat boils. The plant sap and leaves are reputed to be toxic, and decaying leaves from the plant are toxic to other species of plant. The specific epithets *sebifera* and *sebiferum* mean "wax-bearing" and refer to the vegetable tallow that coats the seeds.

The simple, deciduous leaves of this tree are alternate, broad rhombic to ovate in shape and have smooth edges, heart shaped and sometimes with an extended tail often resembling the bo tree, Ficus religiosa. The leaves are bright green in color and slightly paler underneath. They become bright yellows, oranges, purples and reds in the autumn.

The tree is monoecious, producing male and female flowers on the same plant. The waxy green leaves set off the clusters of greenish-yellow and white flowers at bloom time. The flowers occur in terminal spike-like inflorescences up to 20 cm long. Light green in color, these flowers are very conspicuous in the spring. Each pistillate (female) flower is solitary and has a three-lobed ovary, three styles, and no petals.

Common Buckthorn *Rhamnus cathartica*



COMMON BUCKTHORN

Common buckthorn is native to Eurasia and was introduced to North America in the 1880s as an ornamental plant. Its abundant fruit is dispersed by birds and it spreads rapidly, replacing native vegetation and lowering species diversity. Like many non-native shrubs, common buckthorn leafs out early in spring and retains its leaves late into fall, shading out spring wildflowers and tree seedlings. There is some evidence that common buckthorn is allelopathic, producing chemicals that inhibit the growth of other species.

Buckthorn alters ecosystem processes in complex ways. Its leaves and fruit are high in nitrogen. Invasive earthworms, which need rich litter, break it down rapidly, destroying beneficial fungi and exposing bare soils in the process. These soils provide ideal conditions for buckthorn germination and seedling growth but many native trees and shrubs need the beneficial fungi and will not reproduce without it. Common buckthorn is a primary overwintering host for the soybean aphid. It is also an alternate host for alfalfa mosaic virus and crown fungus, which causes oat rust disease.

Identification
Common buckthorn is a deciduous woody shrub or small tree that ranges from 3 to 7.5 m (10-25 ft) in height. When young, it has multiple stems but with age it becomes a tree with a single trunk that may reach 25 cm (10 in) in diameter.

Leaves
Common buckthorn has simple, dark green leaves, with toothed margins and 3 to 5 pairs of prominent leaf veins, which curve as they approach the leaf tip. The leaves are alternate, but some may appear opposite.

DESCRIPTION: Common buckthorn is a shrub or small tree in the buckthorn family (Rhamnaceae) that can grow to 22 feet in height and have a trunk up to 10 inches wide. The crown shape of mature plants is spreading and irregular. The bark is gray to brown, rough textured when mature and may be confused with that of plum trees in the genus Prunus. When cut, the inner bark is yellow and the heartwood, pink to orange. Twigs are often tipped with a spine. In spring, dense clusters of 2 to 6, yellow-green, 4-petaled flowers emerge from stems near the bases of leaf stalks. Male and female flowers are borne on separate plants. Small black fruits about 1/4 inch in cross-section and containing 3-4 seeds, form in the fall. Leaves are broadly oval, rounded or pointed at the tip, with 3-4 pairs of up curved veins, and have jagged, toothed margins. The upper and lower leaf surfaces are without hairs. Leaves appear dark, glossy green on the upper surface and stay green late into fall, after most other deciduous leaves have fallen.

A similar problem exotic species is Rhamnus frangula, glossy buckthorn. Glossy buckthorn does not have a spine at twig tips, leaves are not toothed, and the undersides of the leaves are hairy.

Several native American buckthorns occur in the eastern U.S. that could be confused with the exotic species. If in doubt, consult with a knowledgeable botanist to get an accurate identification. Carolina buckthorn (Rhamnus caroliniana), is a lovely native shrub that has finely toothed leaves somewhat resembling those of black cherry, and are smooth on the underside; it produces attractive fruits from August to October. Alder buckthorn (Rhamnus alnifolia), is a low-growing shrub that may grow to a maximum of 3 feet in height, and has leaves with 6-7 pairs of veins.

ECOLOGICAL THREAT: Exotic buckthorns tend to form dense, even-aged thickets, crowding and shading out native shrubs and herbs, often completely obliterating them. Dense buckthorn seedlings prevent native tree and shrub regeneration. In fire-adapted ecosystems such as savannas and prairies, the lack of vegetation under buckthorn prohibits fires. Buckthorn control is also of interest to small grain producers; the shrub is an alternate host of the crown rust of oats, which affects oat yield and quality.

DISTRIBUTION IN THE UNITED STATES: Common buckthorn has become naturalized from Nova Scotia to Saskatchewan, south to Missouri, and east to New England.

HABITAT IN THE UNITED STATES: Common buckthorn prefers lightly shaded conditions. An invader mainly of open oak woods, deadfall openings in woodlands, and woods edges, it may also be found in prairies and open fields. It is tolerant of many soil types, well drained sand, clay, poorly drained calcareous, neutral or alkaline, wet or dry.

BACKGROUND: Common buckthorn was introduced to North America as an ornamental shrub, for fence rows, and wildlife habitat. Introduction of buckthorn was based on its hardiness and ability to thrive in a variety of soil and light conditions.

BIOLOGY & SPREAD: Common buckthorn is a dioecious plant, meaning that each plant produces only male or female flowers and fruiting trees are always female. Most of the fruits fall directly beneath the shrubs, creating a dense understory of seedlings characteristic of common buckthorn stands. The plentiful fruit is eaten by birds and mice and is known to produce a severe laxative effect, helping distribute seeds through birds, often far from the parent plant. Buckthorn often establishes beneath trees at the edges of forests and fields.

CURRENT MANAGEMENT APPROACHES: Mechanical, physical and chemical methods are available for control of common buckthorn and glossy buckthorn (*Rhamnus frangula*), also an invasive exotic plant. Prescribed fire is one method proposed for controlling buckthorn seedlings in fire-adapted natural areas, from late March to early May, most recently by Boudreau and Wilson. In the upper Midwest conduct burns as soon as leaf litter is dry; resprouts will be less vigorous due to low carbohydrate levels. Burning every year or every other year in established stands may be required for 5-6 years or more.

Unfortunately, buckthorn seedlings often grow in low litter areas, unsuitable for frequent prescribed fire. In dense stands, seedlings and saplings may be cut and dropped on site, creating fuel for future fires. Buckthorn seedlings appear vulnerable to fire, perhaps due to their poorly established root structure. Fire will top kill a mature plant, but resprouting does occur. Uprooting of 1/2 inch diameter seedlings by hand or up to 1 1/2 inch diameter using a weed wrench is effective, but care should be taken to avoid excessive disturbance to the soil, which can release buckthorn seeds stored in the soil.

Careful application of herbicides has been found to effectively control buckthorn in Illinois. The McHenry County, Illinois, Conservation District (MCICD) reports excellent results using a triclopyr herbicide at the rate of 1:4 herbicide to water with dye on cut stumps during the growing season, from late May to October. The product label suggests avoiding treatment during the spring sap flow. To extend the work season, the use of a triclopyr herbicide was also applied to cut stumps during winter and was reported to be effective by MCICD and the Minnesota Region V State Parks.

Frill application (applying herbicide into the cambial layer of fresh cuts on the tree trunk) using the 1:4 rate of triclopyr herbicide with oil and dye was also effective. Experiments at the University of Wisconsin Arboretum report good results using a mixture of 1 part triclopyr herbicide to 7 parts oil on cut stumps, or a 1 part triclopyr herbicide to 16 parts oil mixture applied as a basal bark treatment to stems less than 3 inches across. For fall applications, the Minnesota Department of Natural Resources, Region V State Parks Resource Management has used a 1 part glyphosate herbicide to 5 parts water mixture applied immediately to cut stumps using a hand sprayer. Initial checks indicated over 85 percent control at the test site.

SUGGESTED ALTERNATIVE PLANTS: For home landscaping and wildlife plantings many native low trees and shrubs are available from commercial nurseries. Examples include American elder (*Sambucus canadensis*), Black chokeberry (*Aronia melanocarpa*), and Juneberry (*Amelanchier alnifolia*). Please contact your local native plant society for recommendations of plants native to your particular area.

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Princess Tree
Paulownia tomentosa (Thunb.) Sieb. & Zucc. ex Steud.

PRINCESS TREE

NATIVE RANGE: China

DESCRIPTION: Princess tree, also known as royal paulownia or empress tree, is a small to medium sized tree in the figwort family (Scrophulariaceae) that may reach 30-60 feet in height. The bark is rough, gray-brown, and interlaced with shiny, smooth areas. Stems are olive-brown to dark brown, hairy and markedly flattened at the nodes (where stems and branches meet). Leaves are large, broadly oval to heart-shaped, or sometimes shallowly three-lobed, and noticeably hairy on the lower leaf surfaces. They are arranged in pairs along the stem. Conspicuous upright clusters of showy, pale violet, fragrant flowers open in the spring. The fruit is a dry brown capsule with four compartments that may contain several thousand tiny winged seeds. Capsules mature in autumn when they open to release the seeds and then remain attached all winter, providing a handy identification aid.

ECOLOGICAL THREAT: Princess tree is an aggressive ornamental tree that grows rapidly in disturbed natural areas, including forests, streambanks, and steep rocky slopes.

DISTRIBUTION IN THE UNITED STATES: Princess tree is found in 25 states in the eastern U.S., from Maine to Texas.

HABITAT IN THE UNITED STATES: Princess tree can be found along roadsides, streambanks, and forest edges. It tolerates infertile and acid soils and drought conditions. It easily adapts to disturbed habitats, including previously burned areas, forests defoliated by pests (such as the gypsy moth) and landslides and can colonize rocky cliffs and scoured riparian zones where it may compete with rare plants in these marginal habitats. Its ability to sprout prolifically from adventitious buds on stems and roots allows it to survive fire, cutting, and even bulldozing in construction areas.

BACKGROUND: Princess tree was introduced into the U.S. as an ornamental and landscape tree around 1840. It was first imported to Europe in the 1830's by the Dutch East India Company and brought to North America a few years later. This tree has since become naturalized in the eastern U.S. and is also grown on the west coast. Princess tree is native to western and central China where historical records describe its medicinal, ornamental, and timber uses as early as the third century B.C. It was cultivated centuries ago in Japan where it is valued in many traditions. Recently it has also been grown in plantations and harvested for export to Japan where its wood is highly valued.

BIOLOGY & SPREAD: Princess tree can reproduce from seed or from root sprouts; the latter can grow more than 15 feet in a single season. The root branches are shallow and horizontal without a strong taproot. Seed-forming pollen is fully developed before the onset of winter and the insect-pollinated flowers open in spring.

A single tree is capable of producing an estimated twenty million seeds that are easily transported long distances by wind and water and may germinate shortly after reaching suitable soil. Seedlings grow quickly and flower in 8-10 years. Mature trees are often structurally unsound and rarely live more than 70 years.

CURRENT MANAGEMENT APPROACHES: Princess trees can be controlled using a variety of mechanical and chemical controls. Hand pulling may be effective for young seedlings. Plants should be pulled as soon as they are large enough to grasp. Seedlings are best pulled after a rain when the soil is loose. The entire root must be removed, since broken fragments may resprout. Trees can be cut at ground level with power or manual saws. Cutting is most effective when trees have begun to flower to prevent seed production. Because Princess tree spreads by suckering, resprouts are common after cutting. Cutting should be considered an initial control measure that will require either repeated cutting of resprouts or an herbicidal treatment. Princess tree seedlings and small trees can be controlled by applying a 2% solution of glyphosate (e.g., Roundup) or triclopyr (e.g., Garlon) and water plus a 0.5% non-ionic surfactant to thoroughly wet all leaves. Use a low pressure and coarse spray pattern to reduce damage from spray drift on non-target species. Glyphosate is a non-selective systemic herbicide that may kill non-target plants that are only partially sprayed. Triclopyr is a selective herbicide for broadleaf species. In areas where desirable grasses are growing, triclopyr can be used with minimal non-target damage.

Girdling is effective on large trees where the use of herbicides is impractical. Using a hatchet, make a cut through the bark encircling the base of the tree, approximately six inches above the ground. Be sure that the cut goes well below the bark. This method will kill the top of the tree but resprouts are common and may require a follow-up treatment with a foliar herbicide.

The cut stump method (that is, applying herbicide to freshly cut stumps), should be considered for individual trees or when desirable plants are nearby that might be impacted by foliar applications.

Stump treatments can be used as long as the ground is not frozen. Begin treatments by horizontally cutting stems at or near ground level. Immediately apply a 50% solution of glyphosate or triclopyr and water to the cut stump, making sure to cover the outer 20% of the stump. Basal bark applications are effective throughout the year as long as the ground is not frozen. Apply a mixture of 25% triclopyr and 75% horticultural oil to the base of the tree trunk to a height of 12-15 inches from the ground. Thorough wetting is necessary for good control; spray until run-off is noticeable at the ground line.

SUGGESTED ALTERNATIVE PLANTS: Many native shrubs and trees make excellent alternatives to Princess tree. Examples include serviceberry (*Amelanchier canadensis* and *A. arborea*), redbud (*Cercis canadensis*), flowering dogwood (*Cornus florida*), American holly (*Ilex opaca*), red mulberry (*Morus rubra*), spicebush (*Lindera benzoin*), and sassafras (*Sassafras albidum*). Contact the native plant society in your state for additional recommendations and for information on local sources of native plants.

USE PESTICIDES WISELY: ALWAYS READ THE ENTIRE PESTICIDE LABEL CAREFULLY, FOLLOW ALL MIXING AND APPLICATION INSTRUCTIONS AND WEAR ALL RECOMMENDED PERSONAL PROTECTIVE GEAR AND CLOTHING. CONTACT YOUR STATE DEPARTMENT OF AGRICULTURE FOR ANY ADDITIONAL PESTICIDE USE REQUIREMENTS, RESTRICTIONS OR RECOMMENDATIONS.

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Saltcedar *Tamarix aphylla, T. chinensis, T. gallica, T. parviflora, and T. ramosissima*

NATIVE RANGE: Eurasia and Africa
DESCRIPTION: Most saltcedars, or tamarisks, are deciduous shrubs or small trees growing to 12 -15 feet in height and forming dense thickets. *Tamarix aphylla* is an evergreen tree that can grow to 50 feet tall and tends to flower during the winter. Saltcedars are characterized by slender branches and gray-green foliage. The bark of young branches is smooth and reddish-brown. As the plants age, the bark becomes brownish-purple, ridged and furrowed. Leaves are scale-like, about 1/16 inch long and overlap each other along the stem. They are often encrusted with salt secretions. From March to September, large numbers of pink to white flowers appear in dense masses on 2-inch long spikes at branch tips.
Common Name: saltcedar
Scientific Names: (deciduous) Tamarix ramosissima Ledelbour
T. pentandra Pallas
T. chinensis Loureiro
T. parviflora DeCandolle
T. gallica L.
(evergreen) T. aphylla (L.) Karsten
Family: Tamaricaceae
Taxonomy: Tamarix ramosissima is a Class A noxious weed in many states, and so eradication is required by state law. However, it is very difficult to distinguish one species of saltcedar from another and there is taxonomic disagreement of the deciduous species. They are difficult to distinguish and apparently they have the ability to hybridize. At various times, the deciduous species have been grouped together under T. ramosissima, T. chinensis or T. pentandra, depending on the researcher. The most recent school of thought has this group divided into:
T. parviflora - flowers with 4 sepals and 4 petals
T. ramosissima - flowers with 5 sepals and 5 petals

Comparison of Differences between T. parviflora and T. ramosissima		
Plant Characteristics	Species	Species
	T. parviflora	T. ramosissima
Bark	dark brown to deep purple	reddish brown
Flowering Stems	1-1.5 inch long	3-4 inches long
Flower Parts	4 sepals and 4 petals	5 sepals and 5 petals
Petal Size	1.9 -2.3 mm long	1-1.8 mm long
Flower Color	reddish	pale pink to whitish
Flowering Time	early May to June - Flowers appear before leafing out	May to Oct. until freeze or water loss - Flowers appear after leafing out
Seed Production	about one month	all growing season

ECOLOGICAL THREAT: Saltcedars are fire-adapted species and have long tap roots that allow them to intercept deep water tables and interfere with natural aquatic systems. Saltcedar disrupts the structure and stability of native plant communities and degrades native wildlife habitat by outcompeting and replacing native plant species, monopolizing limited sources of moisture, and increasing the frequency, intensity and effect of fires and floods. Although it provides some shelter, the foliage and flowers of saltcedar provide little food value for native wildlife species that depend on nutrient-rich native plant resources.
DISTRIBUTION IN THE UNITED STATES: Saltcedar occurs in the intermountain region of the western United States, throughout the Great Basin, and California and Texas.

HABITAT IN THE UNITED STATES: Saltcedar establishes in disturbed and undisturbed streams, waterways, bottomlands, banks and drainage washes of natural or artificial waterbodies, moist rangelands and pastures, and other areas where seedlings can be exposed to extended periods of saturated soil for establishment. Saltcedar can grow on highly saline soils containing up to 15,000 ppm soluble salt and can tolerate alkali conditions.

BACKGROUND: Saltcedar was introduced to the western U.S. as an ornamental shrub in the early 1800s.

BIOLOGY & SPREAD: Saltcedar spreads vegetatively, by adventitious roots or submerged stems, and sexually. Each flower can produce thousands of tiny (1/25-inch diameter) seeds that are contained in a small capsule usually adorned with a tuft of hair that aids in wind dispersal. Seeds can also be dispersed by water. Seedlings require extended periods of soil saturation for establishment.

CURRENT MANAGEMENT APPROACHES: Management of saltcedar requires a long term commitment to maintain at low levels and prevent reinfestation. A variety of methods have been used in the management of saltcedar, including mechanical, chemical and biological. The most effective management probably involves a combination of these. Mechanical techniques include hand-pulling, digging, root-cutting, use of weed eaters, axes, machetes, bulldozers, fire and flooding. Removal by hand is generally recommended for small infestations of saplings under 1-inch diameter. Root-cutting and bulldozing may be effective but are costly, labor intensive, and may cause extensive damage to soils and lead to resprouting. Fire has been used with some success, but because saltcedars are fire-adapted, they readily resprout after fire. Flooding can be used to control salt cedar if root crowns remain submerged for at least three months.

For extensive infestations of saltcedar, chemical control has been shown to be the most effective method. Cautious use of herbicides aids in restoration of saltcedar infested sites by allowing repopulation by native plant species.

Systemic herbicides (e.g., those that kill the plant from the root up) are recommended for saltcedar management and application methods include foliar sprays, cut stump treatments, basal bark treatments, and aerial sprays. Because tamarisk usually grows in or adjacent to streams, wetlands and other waterways, it is important to use products registered for aquatic application.

Fifteen insects are being investigated as potential biological control agents for saltcedar. Two of these, a mealybug (*Trabutina mannipara*) and a leaf beetle (*Diorhabda elongata*), have preliminary approval for release. Five others are being tested within the United States and an additional eight species are under study overseas. Final approval for release of the mealybug and the leaf beetle is pending resolution of concerns regarding their potential impact to the southwestern subspecies of the willow flycatcher (*Empidonax trailii extimus*), a federally endangered bird. In parts of its range where native willows, its natural nest trees, have been replaced by saltcedar, the willow flycatcher now utilizes it for this purpose. Concern is over the possibility that, due to the environmental damage caused by tamarisk, native plant species may not be able to replace it if the biological control agents succeed in eliminating it.

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Reclaiming the Puerco River Article

A New Mexico conservation district works to rid the area of salt cedar

By Vince Bossany
Special to ESPNOutdoors.com

When the McKinley Soil and Water Conservation District of Gallup, New Mexico, started exploring options for a comprehensive river restoration project, board members knew they had to start with the basics.

Although the board's ambitious plans included the restoration of a local river, the re-introduction of native plant and animal habitat and the eventual creation of a new wetland park area near Gallup, the board decided to first deal with a local infestation of salt cedar, an invasive, non-native plant that threatens water supplies throughout the West.

Local water conservation boards, land managers and governmental bodies generally rely on one of several different methods to control salt cedar, including physical removal and through the application of herbicides that negatively affect salt cedar.

"All over the West, there's a fevered debate over water," said Larry Winn, chairperson of the McKinley Soil and Water Conservation District in Gallup. "A large portion of that debate is focused on how water is being wasted. Communities like ours struggle with saving water, getting water and living in a desert, while still trying to maintain the natural beauty of plants, trees, and rivers. Because of this debate, we realized that we needed to start with a salt cedar eradication project before we could bring back our river."

Salt cedar currently infests an estimated 1.5 million acres along waterways in the western United States. As a wily competitor for resources, a single acre of the invasive plant can suck up more than 2.8 million gallons of water in a single year, according to researchers from the Texas Cooperative Extension. Like hundreds of other communities throughout the western United States, Gallup's Rio Puerco river basin is heavily infested with the invasive tree.

Restoring the Rio Puerco of the West

Gallup's Puerco River — known as the Rio Puerco of the West — is an ephemeral stream that runs through the city alongside the famed Route 66 highway. Like other ephemeral streams in arid northwest New Mexico and northeast Arizona, the Rio Puerco of the West usually only flows after occasional summer rains or when mountain snows melt in the spring. In general, it runs for just a few days or weeks each year, and lies dusty and barren the rest of the time.

Arsenal herbicide can provide effective salt cedar control without negatively affecting most grasses, forbs and legumes — which serve as prime wildlife forage and habitat.

“Today, the only place the river flows with any regularity is downstream of our water treatment plant, where treated effluent is released to mimic a perennial stream," Winn said. "We hope to change that by getting rid of salt cedar and restoring the river's natural flow using effluent from a new reverse-osmosis water treatment plant."

At present, the Rio Puerco's natural streambed parallels an effluent ditch from Gallup's water treatment plant. The water conservation district plans to rehabilitate a two-mile section of the natural streambed, first by eradicating salt cedar along the stream, then by using treated effluent to mimic a perennial stream. The treated water will come from a state-of-the-art reverse osmosis water treatment plant scheduled to open in just over a year. When the entire project is complete, the board hopes to install a series of footbridges over the river and create a 10,000-acre nature park.

"What we hope to do is bring the river back and reintroduce a certain interest in the proper scale of living in the desert," Winn said. "We want to create an appreciation for the natural world in our community. As we restore the river, we restore ourselves."

Before such long-term objectives can be reached, however, the McKinley Soil and Water Conservation District is taking key steps to eradicate the negative effects caused by the region's salt cedar infestation.

About Salt Cedar

Salt cedar, or tamarisk, is the common name for a species of exotic, invasive trees or shrubs inflicting significant damage on stream banks and waterways throughout the United States.

A salt cedar infestation can destroy wildlife habitat by sucking millions of gallons of water from streams, rivers, and lakes.

Originally imported from Eurasia to serve as a shade plant and erosion-prevention tool in arid regions of the western United States, salt cedar is today one of the most invasive nonnative plants in America. The species has invaded approximately 29,000 acres on 33 national wildlife refuges managed by the U.S. Fish and Wildlife Service.

An exotic plant that generally grows to around 20 feet tall, salt cedar has long taproots that allow it to intercept deep water tables and interfere with natural aquatic systems. Salt cedar can consume twice the water of native plants such as willow trees. Experts estimate that each salt cedar tree along the Pecos River in Texas uses 14,000 gallons annually — or 78 gallons per tree, per day.

Like many invasive plant species, salt cedar has an exceptionally strong reproductive capability. A mature salt cedar plant can produce 600,000 seeds annually. After summer rains, seedlings can quickly colonize moist areas due to the constant availability of seeds. A mature salt cedar plant can also reproduce vegetatively, meaning its roots, cuttings, and branches have the ability to resprout when detached.

Salt cedar trees can live 50 to 100 years and generally grow from four to 26 feet tall. A single tree can grow nine to 12 feet in a single season under good conditions. During a normal spring, it can grow as much as one foot per month.

The weed is highly adapted to arid climates, thriving in salty, nutrient-poor soil. It is also extremely resistant to adverse environmental conditions such as drought or flooding. During a drought, the invasive weed survives by dropping its leaves and halting growth to conserve water and nutrients. Under flooding, it can survive immersion in water for up to 70 days.

Salt cedar has invaded waterside ecosystems throughout the southwestern United States. Prevalent in Texas, New Mexico, Arizona and Utah, salt cedar also extends north to Colorado, Indiana, Kansas, Massachusetts, Missouri, Nebraska and Oklahoma. Well-established stands can also be found along waterways in Idaho, Montana, Oregon, South Dakota and Wyoming.

Highly Destructive Plant

Salt cedar poses a severe threat to the structure and stability of native plant communities throughout the United States. The invasive plant draws salt from deep in the soil and exudes it via glands in its leaves. As rain washes the salt off the leaves and into the soil, the resulting increase in salinity kills understory plants and inhibits surrounding native plants from growing.

Salt Cedar's pleasant appearance comes at a high price, as each plant can consume up to 200 gallons of water a day.

From the southwestern United States up through Montana, stands of salt cedar have severely limited the number of germination sites suitable for native waterfront species such as willow and cottonwood. The foliage and flowers of salt cedar provide little food value for native wildlife species, which depend on nutrient-rich native plant species.

Numerous studies have shown that stands of salt cedar can seriously degrade natural habitats. Salt cedar infestations can displace or replace native plant communities, degrade wildlife habitat and contribute significantly to the decline of many native species, including several threatened or endangered species.

Along the lower Colorado River, for example, an influx of salt cedar into native habitats seriously threatens nine bird species. According to a report by the California Department of Fish and Game, two native bird species have been completely eliminated from the area. Seven other species are in serious decline, including the elf owl, Bell's vireo, Gila woodpecker, gilded northern flicker, vermilion flycatcher, summer tanager and western yellow-billed cuckoo.

Because salt cedar branches can form dense thickets many feet wide, the plant can impede wildlife access to water sources. In the waterways themselves, salt cedar adversely affects many fish species by creating narrow, homogenous stream habitats and reducing the number and variety of insects used as a food source.

Cattle and other livestock usually don't prefer salt cedar as a food source because it quickly grows taller than they can reach. Salt cedar can actually reduce a rangeland's livestock capacity by displacing forage grasses, increasing soil salinity, raising the incidence of fires and using groundwater or irrigation water that could otherwise be available to grow forage plants.

Bringing a river back from the desert

In Gallup, Winn said the idea to remove salt cedar came about after he saw how much affected ecosystems can improve after the plant is brought under control. Studies show that removing salt cedar infestations can improve both quantity and quality of water, help to rejuvenate underground springs, increase stream flow and return wetlands to their intended state.

> *" I think bringing back the river is a metaphor for bringing life back to people and our region. Restoring it can help improve the quality of life in our community. "*
>
> *— Larry Winn, chairperson of the McKinley Soil and Water Conservation District in Gallup, New Mexico*

"Last year, I attended a workshop for stream health in Santa Fe, New Mexico, near the Santa Fe River — which is in the same situation as our Rio Puerco," Winn said. "It generally doesn't flow except for annual rains and the introduction of treated effluent. The city of Santa Fe got permission to restore a streamside riparian forest area that once existed there, and it just looked wonderful. After seeing their remarkable success, I came back to Gallup and started talking it up around town. People here were very receptive and interested."

Because salt cedar is so well adapted to harsh conditions, controlling the plant can often be difficult and costly, depending on the measures used. Local water conservation boards, land managers and governmental bodies generally rely on one of several different methods to control salt cedar, including physical removal — either by hand or through mechanical means — and through the application of special targeted herbicides that negatively affect salt cedar.

The McKinley Soil and Water Conservation District in Gallup opted to use a newer tactic: the application of a new, smart herbicide developed by BASF Corporation. Unlike most other herbicides on the market, Arsenal herbicide from BASF can provide effective salt cedar control without negatively affecting most grasses, forbs and legumes — which serve as prime wildlife forage and habitat. The herbicide, which is typically applied in late summer to fall for maximum effectiveness, works by inhibiting three key amino acids essential to plant growth. The herbicide translocates to the roots and shoots and inhibits a specific enzyme that causes the salt cedar to stop growing and slowly die as its nutrient reserves are exhausted.

In Gallup, a recent salt cedar-eradication demonstration project used helicopters, GPS guidance and other tools to target herbicide delivery specifically to a two-mile stretch of salt cedar-infested riverbank areas. The treated areas are owned by the city of Gallup and three other landowners — all of which agreed to participate in the salt cedar eradication test project. The parties involved agreed to the project in part after learning that Arsenal herbicide breaks down quickly in the soil, allowing desirable grasses, forbs and legume species to germinate and repopulate a treated site. Because it is considered a low-volume herbicide, it provides more control with less chemical load on the environment, compared to other herbicides.

Biological control efforts

Scientists are currently investigating the use of non-native insects as potential biological control agents for salt cedar in the United States. Two insects, Trabutina mannipara (a mealybug from Israel) and Diorhabda elongate (commonly known as the Asian leaf beetle), are natural predators for salt cedar and have been approved for release by the U.S. Department of Agriculture.

In 2001, researchers released Asian leaf beetles in field sites throughout the West. However, it will likely be several years before the leaf beetle's success can be seen. According to scientists, even if the beetle is effective, the insect only provides around 75-80 percent control of salt cedar and may take as much as 10 years before results are noticeable.

Salt cedar eradication gains momentum in other communities

And, since the insects rely on salt cedar as a food source, they are unlikely to control all salt cedar plants. In a best-case scenario, the Asian leaf beetle would serve as means of damaging — but not eradicating — stands of salt

Several communities in the West and Southwest have used Arsenal with significant success. In the 1990s, the U.S. Fish and Wildlife Service began using BASF's Arsenal as part of an extensive, long-running campaign to eradicate salt cedar in the Bosque del Apache National Wildlife Refuge near Socorro, New Mexico.

Aimed at rehabilitating salt cedar-infested floodplains and restoring diverse riparian habitats, the program used Arsenal in a number of different combinations to test for the most effective application methods. A study conducted by researchers from New Mexico State University found that a helicopter application of Arsenal alone provided 90 percent or greater control of salt cedar.

Similarly, as part of a salt cedar-control program still underway in Texas, Arsenal is being applied with significant success in key salt cedar-infested areas along the Pecos River. Between 1999 and 2002, the Texas Cooperative Extension used Arsenal to treat approximately 6,341 acres of salt cedar along 120 miles of the Pecos River.

After just three years of treatments, salt cedar control efforts have salvaged just under 12 billion gallons of water — roughly enough water to serve a city the size of Lubbock, Texas, for a year. No significant re-invasion of salt cedar has occurred in the Arsenal herbicide-treated areas and annual water savings in 2003 are estimated to increase to 15.9 billion gallons.

Hopeful for the future

Although salt cedar continues to aggressively attack the environment by infesting millions of acres of land and displacing native habitat, the development of innovative solutions, such as Arsenal, are finally enabling landowners and managers to take firm control of the problem. The result is the ability to reclaim precious land and water resources — saving ecosystems, wildlife and livelihoods.

In Gallup, the McKinley Soil and Water Conservation District hopes that its first demonstration test using Arsenal will encourage other communities downstream in New Mexico and Arizona to consider similar eradication tactics and river-restoration programs.

"There are many communities downstream that have water treatment plans along the Rio Puerco and the Little Colorado," Winn said. "If we can get other states and water boards interested in salt cedar eradication and high-tech water treatment systems, we can create significant stretches of river that run year-round."

Winn said he hopes the demonstration project will renew interest in salt cedar control and increase the likelihood of larger application projects.

"If we can bring back this river one stretch at a time, we have, in effect, brought back life within ourselves," Winn said. "I think bringing back the river is a metaphor for bringing life back to people and our region. Restoring it can help improve the quality of life in our community."

BASF is a sponsor of ESPNOutdoors.com. For more information on selective herbicides and forestland or wildlife management, please visit their website at www.forestryfacts.com.

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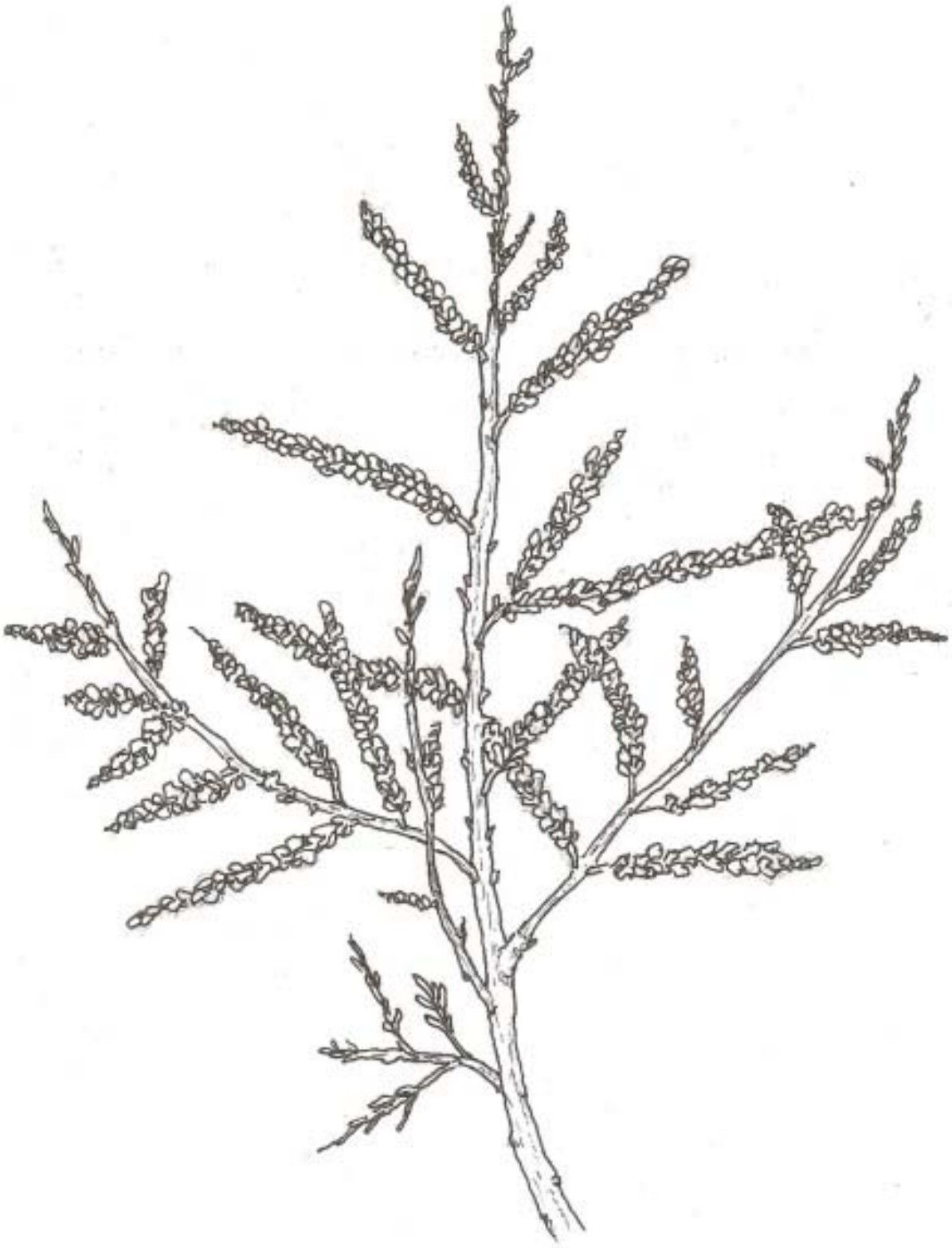

SALTCEDAR

Siberian Elm - *Ulmus pumila* L.

NATIVE RANGE: Northern China, eastern Siberia, Manchuria and Korea

DESCRIPTION: Siberian elm is a fast-growing tree in the elm family (Ulmaceae) distinguished by small toothed leaves about 1-2½ in (3-7 cm) long and half as wide, and pointed at the tip. Unlike other elms, the leaf base is usually symmetrical, forming a nearly even "V". Leaves are smooth and dark green above, paler and nearly hairless beneath, and alternate from side to side along twigs. Mature trees reach a height of 50-70 ft. (16-22 m.), with a round crown of slender, spreading branches. The bark is rough, gray or brown, and shallowly furrowed at maturity. Twigs are nearly hairless with small, blunt buds. Flowering occurs in the springtime. The small greenish flowers lack petals and occur in drooping clusters of 2 to 5. After flowering, a single seed forms in the center of each smooth, flattened, circular, ½ in (10-15 mm) wide fruit.

Other species of elms (*Ulmus*) and the close relative *Zelkova*, especially younger plants, look similar to Siberian elm. Some may even confuse it with choke-cherry (*Prunus serotina*) and hackberry (*Celtis* sp.). The native slippery elm and American elm typically have leaves that are greater than 3 in (7.3 cm) long, with unequal heart-shaped leaf bases, and leaf margins with double teeth.

ECOLOGICAL THREAT: Dry to mesic prairies and stream banks are vulnerable to Siberian elm invasion. Thickets of seedlings soon form around seed-producing trees, bare ground areas, animal and insect mounds, and other disturbed areas. Wind carries seed to distant areas where new colonies can form. This tough exotic survives under conditions not easily tolerated by other species, allowing it to take advantage of open ground and resources otherwise used by native plants. Fast growing seedlings of Siberian elm quickly overtake native vegetation, especially shade-intolerant species. This often leads to invasion by additional weedy species, compounding the problem.

DISTRIBUTION IN THE UNITED STATES: Siberian elm is known to occur in 43 states and reported to be invasive in natural areas in 25 states (AZ, IA, ID, IL, IN, KS, KY, MA, MD, MI, MN, MO, NE, NM, NV, OH, OK, OR, PA, TX, UT, VA, WA, WI, WV).

HABITAT IN THE UNITED STATES: Dry and mesic prairies and areas along stream banks in Minnesota and forested areas and high elevations in Arizona.

BACKGROUND: Siberian elm was introduced to the U.S. in the 1860's for its hardiness and fast growth in a variety of moisture regimes and habitats, including droughts and cold winters. It is resistant to Dutch elm disease. This elm continues to be promoted, especially in the Great Plains, in spite of weak limbs and susceptibility to insect attack.

BIOLOGY & SPREAD: Seeds are produced early in spring and spread by the wind. Germination rate is high and seedlings soon establish in the bare ground found early in the growing season.

CURRENT MANAGEMENT APPROACHES: For long term management of Siberian elm, reduction of seed sources is essential.

Chemical. To avoid resprouts after cutting or girdling, cut stumps may be treated with systemic herbicides such as glyphosate (e.g., Roundup) and triclopyr (e.g., Garlon).
After spring sap flow ceases and during the growing season, Minnesota DNR State Parks Southern Region Resource Management applies 4 parts water to 1 part glyphosate (based on 41% active ingredient glyphosate concentrate) with a hand sprayer to cut stumps. The entire stump should be saturated with the herbicide to achieve the most effective control. Garlon 4 (triclopyr ester formulation) can be applied as a cut stump or basal bark treatment. For basal bark, apply a 20-percent solution in horticultural oil (2.5 quarts per 3-gallon mix) with a penetrant (check with herbicide distributor) to young bark as a basal spray in winter (January to February) or summer-fall (June to October). Cut stems can be immediately treated with glyphosate herbicide as a 20-percent solution (2.5 quarts per 3-gallon mix) in water with a surfactant.

Manual. During the growing season, seedlings can be hand pulled and small trees carefully removed by a grub hoe or weed wrench. Trees girdled in mid-May to early July will die over 1-2 years without sprouting if cut properly. To remove a band of bark from the wood, make two parallel cuts 3-4 inches apart, then knock bark off with a blunt object such as the back of an axe head or dull end of a girdling bar. The xylem must remain intact; if girdled too deeply the tree will respond as if cut down and will resprout. On sites with few seed sources, the large trees can be cut down and resprouts trimmed as needed.

Other. A regular regime of prescribed burning in fire-adapted communities will kill seedlings.

SUGGESTED ALTERNATIVE PLANTS: When planting shade trees near prairie sites, consider using trees native to your area, especially those that are not prolific colonizers. Some appropriate examples are bur oak (*Quercus americana*) or other oaks native to your area, and basswood (*Tilia americana*). Check with your state native plant society or the Lady Bird Johnson Wildflower Center's Native Plant Information Network for recommendations.

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Silk Tree *Albizia julibrissin* Durz.

NATIVE RANGE: Iran to Japan (according to Hortus 3rd. ed.).
DESCRIPTION: Silk tree, also known as mimosa, or silky acacia, is a small to medium-sized tree in the pea family (Fabaceae) that can grow up to 20-40 feet tall. The bark is light brown, nearly smooth, and generally thin with lens shaped areas along the stem. The attractive fern-like leaves of mimosa are finely divided, 5-8 inches long by about 3-4 inches wide, and alternate along the stems. Silk tree has showy and fragrant pink flowers, about 1½ inches long, that resemble pom-poms and are arranged in panicles at the ends of branches. Fruits are flat, straw-colored pods about 6 inches long containing light brown oval-shaped seeds about ½ inch in length. Pods ripen in August to September and begin to disintegrate soon after, but remain on the trees into winter.
ECOLOGICAL THREAT: Because silk tree can grow in a variety of soils, produce large seed crops, and resprout when damaged, it is a strong competitor to native trees and shrubs in open areas or forest edges. Dense stands of mimosa severely reduce the sunlight and nutrients available for other plants.
DISTRIBUTION IN THE UNITED STATES: Silk tree is naturalized from New Jersey to Louisiana and in California.
HABITAT IN THE UNITED STATES: Silk tree takes advantage of disturbed areas, often spreading by seed from nearby ornamentals or from contaminated fill dirt. It prefers full sun and is often seen along roadsides and open vacant lots in urban/suburban areas. Silk tree can tolerate partial shade but is seldom found in forests with full canopy cover, or at higher elevations (above 900 m or 3,000 ft), where cold hardiness is a limiting factor. It can, however, become a serious problem along riparian areas, where it becomes established along scoured shores and where its seeds are easily transported in water. Like many successful exotics, it is capable of growing in a wide range of soil conditions.
BACKGROUND: Silk tree was introduced to the U.S. in 1745. Silk tree continues to be a popular ornamental because of its fragrant and showy flowers.
BIOLOGY & SPREAD: Silk tree reproduces both vegetatively and by seed. Silk tree seeds have impermeable seed coats that allow them to remain dormant for many years. One study showed that 90% of the seeds were viable after five years and, for another species of mimosa, a third of its seeds germinated after 50 years in open storage. Seeds are mostly dispersed below or around the parent plant, but can be dispersed further by water. Silk trees grow rapidly under good conditions but are short-lived and have weak, brittle wood. If cut or top-killed, trees resprout quickly and sprouts can grow over three feet in a season.
CURRENT MANAGEMENT APPROACHES: Silk tree can be controlled using a variety of mechanical and chemical controls. Trees can be cut at ground level with power or manual saws. Cutting is most effective when trees have begun to flower to prevent seed production. Because mimosa spreads by suckering, resprouts are common after treatment. Cutting is an initial control measure and will require either an herbicidal control or repeated cutting for resprouts.

Girdling is effective on large trees where the use of herbicides is impractical. Using a hatchet, make a cut through the bark encircling the base of the tree, approximately six inches above the ground. Be sure that the cut goes well below the bark. This method will kill the top of the tree but resprouts are common and may require a follow-up treatment with a foliar herbicide.

Hand pulling will effectively control young seedlings. Plants should be pulled as soon as they are large enough to grasp, but before they are old enough to flower. Seedlings are best pulled after a rain when the soil is loose. The entire root must be removed since broken fragments may resprout.

Silk tree seedlings and small trees can be controlled by applying a 2% solution of glyphosate (e.g., Roundup) or triclopyr (e.g., Garlon) and water plus a 0.5% non-ionic surfactant to thoroughly wet all leaves. Systemic herbicides such as glyphosate and triclopyr can kill entire plants because the chemicals travel through a plant from the leaves and stems to the actively growing roots, where they prevent further cell growth. Use a low pressure and a coarse spray pattern to reduce damage from spray drift on non-target species. Use caution when applying these products, as glyphosate is a non-selective herbicide that may kill non-target plants that are only partially contacted. Triclopyr is a selective herbicide for many broadleaf plant species.

Triclopyr is a selective herbicide for many broad-leaved plant species and should be considered for sites where native or other desirable grasses are meant to be conserved.

The cut-stump and basal bark herbicidal methods should be considered when treating individual trees or where the presence of desirable species preclude foliar application. Stump treatments can be used as long as the ground is not frozen. Horizontally cut stems at or near ground level. And immediately apply a 25% solution of glyphosate or triclopyr and water to the cut stump, making sure to cover the outer 20% of the stump.

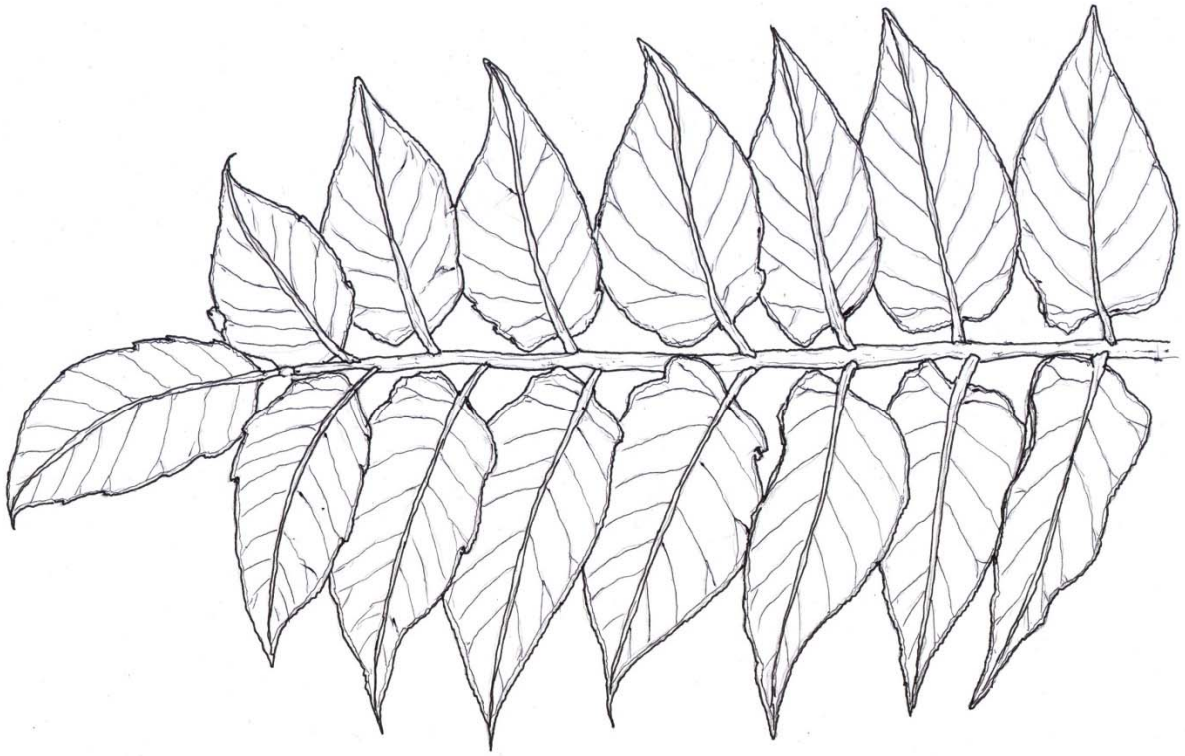
Basal bark applications are effective throughout the year as long as the ground is not frozen. Apply a mixture of 25% triclopyr and 75% horticultural oil to the base of the tree trunk to a height of 12-15 inches from the ground. Thorough wetting is necessary for good control; spray until run-off is noticeable at the ground line.

SUGGESTED ALTERNATIVE PLANTS: Many small to medium-sized trees make excellent alternatives to silk tree. A few examples include serviceberry (*Amelanchier arborea*), redbud (*Cercis canadensis*), flowering dogwood (*Cornus florida*), river birch (*Betula nigra*), fringe tree (*Chionanthus virginicus*), American holly (*Ilex opaca*), and sweetgum (*Liquidambar styraciflua*). Check with the native plant society in your state for plant recommendations for your particular area.

USE PESTICIDES WISELY: ALWAYS READ THE ENTIRE PESTICIDE LABEL CAREFULLY, FOLLOW ALL MIXING AND APPLICATION INSTRUCTIONS AND WEAR ALL RECOMMENDED PERSONAL PROTECTIVE GEAR AND CLOTHING. CONTACT YOUR STATE DEPARTMENT OF AGRICULTURE FOR ANY ADDITIONAL PESTICIDE USE REQUIREMENTS, RESTRICTIONS OR RECOMMENDATIONS.

NOTICE: MENTION OF PESTICIDE PRODUCTS IN THIS COURSE DOES NOT CONSTITUTE ENDORSEMENT OF ANY MATERIAL.

Tree-of-Heaven *Ailanthus altissima* (Mill.) Swingle



TREE OF HEAVEN

NATIVE RANGE: Central China
DESCRIPTION: Tree-of-heaven, also known as ailanthus, Chinese sumac, and stinking sumac, is a rapidly growing, deciduous tree in the mostly tropical quassia family (Simaroubaceae). Mature trees can reach 80 feet or more in height. Ailanthus has smooth stems with pale gray bark, and twigs which are light chestnut brown, especially in the dormant season. Its large compound leaves, 1-4 feet in length, are composed of 11-25 smaller leaflets and alternate along the stems. Each leaflet has one to several glandular teeth near the base. In late spring, clusters of small, yellow-green flowers appear near the tips of branches. Seeds are produced on female trees in late summer to early fall, in flat, twisted, papery structures called samaras, which may remain on the trees for long periods of time. The wood of ailanthus is soft, weak, coarse-grained, and creamy white to light brown in color. All parts of the tree, especially the flowers, have a strong, offensive odor, which some have likened to peanuts or cashews.

NOTE: Correct identification of ailanthus is essential. Several native shrubs, like sumacs, and trees, like ash, black walnut and pecan, can be confused with ailanthus. Staghorn sumac (*Rhus typhina*), native to the eastern U.S., is distinguished from ailanthus by its fuzzy, reddish-brown branches and leaf stems, erect, red, fuzzy fruits, and leaflets with toothed margins.

ECOLOGICAL THREAT: Tree-of-heaven is a prolific seed producer, grows rapidly, and can overrun native vegetation. Once established, it can quickly take over a site and form an impenetrable thicket. Ailanthus trees also produce toxins that prevent the establishment of other plant species. The root system is aggressive enough to cause damage to sewers and foundations.

DISTRIBUTION IN THE UNITED STATES: Tree-of-heaven is widely distributed across the United States, occurring in forty-two states, from Maine to Florida and west to California.

HABITAT IN THE UNITED STATES: Tree-of-heaven is a common tree in disturbed urban areas, where it sprouts up just about anywhere, including alleys, sidewalks, parking lots, and streets. The book “A Tree Grows in Brooklyn”, by Betty Smith is based on the ailanthus tree. Away from cities, it is commonly seen in fields and along roadsides, fencerows, woodland edges and forest openings.

Nationally, ailanthus has become an agricultural pest and may occur as seedlings that pop up by the hundreds in recently planted fields, or as persistent thickets in rocky, untillible areas.

BACKGROUND: Tree-of-heaven was first introduced to America by a gardener in Philadelphia, PA, in 1784, and by 1840 was commonly available from nurseries. The species was also brought into California mainly by the Chinese, who came to California during the gold rush in the mid-1800s. Today it is frequently found in abandoned mining sites there. The history of ailanthus in China is as old as the written language of the country.

BIOLOGY & SPREAD: Tree-of-heaven reproduces both sexually (seeds) and asexually (vegetative sprouts). Flowering occurs late in the spring (June in the middle Atlantic region of eastern U.S.). The species is dioecious, with male and female flowering on separate trees. Fruits are papery, somewhat twisted, winged structures called samaras that are tan to pink-colored. Samaras occur in large clusters from September to October of the same year, and may persist on the tree through the following winter. One study reports that an individual tree can produce as many as 325,000 seeds per year. Established trees also produce numerous suckers from the roots and resprout vigorously from cut stumps and root fragments.

CURRENT MANAGEMENT APPROACHES: Elimination of Ailanthus requires diligence, due to its abundant seed production, high seed germination rate, and vegetative reproduction. Follow-up monitoring and treatment when needed should be an integral part of any serious ailanthus management program. Regardless of method selected, treated areas should be rechecked one or more times a year and any new suckers or seedlings treated (cut, sprayed or pulled) as soon as possible, especially before they are able to rebuild root reserves. Establishing a thick cover of trees (preferably native and non-invasive) or grass sod will help shade out and discourage establishment of ailanthus seedlings. Targeting large female trees for control will help reduce spread of ailanthus by seed.

Young seedlings may be pulled or dug up, preferably when soil is moist. Care must be taken to remove the entire plant, including all roots and fragments, as these will almost certainly re-grow. Root suckers appear similar to seedlings, but would be connected to a pre-existing lateral root, and would be nearly impossible to remove effectively.

Cutting alone is usually counter-productive because ailanthus responds by producing large numbers of stump sprouts and root suckers. However, for small infestations, repeated cutting of sprouts over time can exhaust the plants reserves and may be successful if continued for many years or where heavy shade exists. If possible, the initial cutting should be in early summer in order to impact the tree when its root reserves are lowest. Cutting large seed producing female trees would at least temporarily reduce spread by this method.

The most effective method of ailanthus control seems to be through the use of herbicides, which may be applied as a foliar (to the leaves), basal bark, cut stump, or hack and squirt treatment. Keep in mind that it is relatively easy to kill the above ground portion of ailanthus trees--you need to kill or seriously damage the root system to prevent or limit stump sprouting and root suckering. Always be extremely careful with herbicide applications in the vicinity of valuable ornamental shrubs and trees.

Foliar sprays applied when trees are in full leaf are very effective, and should be the method of choice where ailanthus size and distribution allows effective spray coverage of all foliage without unacceptable contact with nearby desirable vegetation or the applicator. Where ailanthus is in association with other exotic weed species, as is often the case, foliar spray allows treatment of the entire area at one time. Limitations of the method are the seasonal time frame, the need to transport a larger, more diluted volume of spray material, and the fact that rapid growing ailanthus are often out of effective reach.

The non-selective herbicide glyphosate (e.g., Roundup, Rodeo, Accord), will kill or injure almost any plant, herbaceous or woody, contacted by the spray. Triclopyr (e.g., Garlon 3A, Garlon 4) is selective for broadleaf and woody plants and will not kill grasses contacted by the spray. Both glyphosate and triclopyr are systemic herbicides, meaning that they are absorbed by plants and are carried to the root systems. These herbicides have low soil activity, so do not pose a threat to groundwater if applied properly and at recommended label rates. Both glyphosate and triclopyr should be mixed with water and a small amount (0.5%, or as per label) of a non-ionic surfactant (except for Roundup, which contains a surfactant) to help the spray spread over and penetrate the leaves. The mixture should be applied to leaves and green stems, including sprouts and suckers, until thoroughly wet but not to the point of runoff. With backpack sprayers, concentrations of 2% of a typical glyphosate product such as Roundup or Accord applied June 15 - September 15, or 1.5% of a 4 lb./gallon triclopyr product such as Garlon 4, or 2% of a 3 lb./gallon triclopyr product such as Garlon 3A applied June 1 - September 1 have worked well in the Mid-Atlantic area, with slightly greater effectiveness for the triclopyr products. For higher volume applications such as would be applied by a truck mounted sprayer, the concentration for these products could be reduced by 0.5% to 1-1.5%. Other herbicides which have shown to be effective for foliar application of ailanthus are dicamba (e.g., Banvel, Vanquish), imazapyr (e.g., Arsenal, Chopper), and metsulfuron methyl (e.g., Escort).

Basal bark application is one of the easiest methods and does not require any cutting. It works best during late winter/early spring and in summer. The base of the tree stem must be free of snow, ice, or water on the bark from recent rainfall, though precipitation following application is inconsequential. Late winter/early spring (February 15 -April 15, Mid-Atlantic) is generally the most productive time, since vegetation near the base of the trees is usually absent or leafless. Late spring and early summer applications (April 15 - June 1, Mid-Atlantic), when plant fluids are moving upwards to support new growth, are questionable.

Application during the summer (June 1 - September 15, Mid-Atlantic) works very well as long as vegetation is not a hindrance, and allows lower concentrations of herbicide to be used. Fall to mid-winter applications (October - January) have given poor results. Mix up a solution of 20% (as low as 10% in summer depending on objectives) concentration of oil-soluble triclopyr product (e.g., Garlon 4) in 80% oil (fuel oil, diesel, kerosene, mineral oil, or special vegetable oils). With these diluents some applicators add a pine oil based additive (e.g., Cide-Kick II) at the rate of 10%, which helps penetrate the bark and eliminate any unpleasant odor. Some companies market diluents based on mineral or vegetable oils specifically designed for basal bark application, which should be considered for use in sensitive areas. Another option is to use a pre-mixed, ready-to-use triclopyr product designed for basal bark (and cut stump) application (e.g., Pathfinder II). Using a handheld or backpack type sprayer, apply the mixture in a 12 inch wide band around the entire circumference of the tree base with no “skips”. The basal bark method is generally used for trees that are less than 6 inches in diameter, though slightly larger stems may also be treated effectively by thoroughly treating bark up to 24 inches in height.

Follow-up foliar herbicide application (see above) to basal sprouts and root suckers may be necessary. Another herbicide which has been shown to be effective for basal bark control of ailanthus is imazapyr (e.g., Chopper, Stalker). This is sometimes used in a combination with triclopyr at a concentration of 15% Garlon 4 and 5% Stalker in 80% oil diluent.

Root suckering will be an increasing problem in the fall, winter and spring. The hack-and-squirt (or injection) method is very effective and minimizes sprouting and suckering when applied during the summer. This method requires first making downward-angled cuts into the sapwood around the tree trunk at a comfortable height, using a hand ax. With spray bottle or wand in the other hand, squirt a straight (100%) concentration of a water-soluble triclopyr product (e.g., Garlon 3A) into the cuts within a minute or two, applying 1-2 milliliters into each cut (typically 1-2 squirts of a trigger squirt bottle) so that the bottom of the cut is covered, but liquid doesn't run out of it.

Generally, you would make about 1 hack cut for each inch of diameter plus one (i.e., for a 10 inch diameter tree, make about 11 cuts). Space the cuts so that about 1-2 inches of uncut living tissue remains between them.

A continuous line of cuts around the trunk would likely cause the tree to go into emergency response mode and react by producing basal sprouts and root suckers. For this reason, girdling or frilling (girdling followed by herbicide) is not highly recommended unless long term follow-up treatment is possible.

While spaced injection works well for ailanthus, it is not as effective on some other species. This method can be used with trees of any size, though it is most productive with stems over 2 inches in diameter. This method is relatively easy for one person to do, with hatchet in one hand and spray bottle in the other, but should be done with a buddy nearby in case of an accident. Monitor the treatment area and be prepared to follow-up with a foliar application the next year to control any basal sprouts or root suckers that might emerge. Glyphosate products have sometimes been recommended for control of ailanthus using this method, but several field trials have shown consistently poor long-term control of basal sprouts and root suckers at any time of year. Other herbicides which have shown to be effective for hack-and-squirt control of ailanthus during the growing season are dicamba (e.g., Banvel, Vanquish), imazapyr (e.g., Arsenal A.C., Chopper), and 2,4-D + picloram (e.g., Pathway). Dicamba is particularly effective in October.

The cut stump method is useful in areas where the trees need to be removed from the site and will be cut as part of the process. While situations exist that dictate this method over the others given above, felling trees is usually less effective in killing the root system, slower, more labor intensive, and more hazardous to personnel than other methods.

This method is likely to be most successful during the growing season, with diminishing success through the early fall. Dormant season applications may prevent resprouting from the stump itself, but will do little to inhibit root suckering. However, at any time of year, if the tree must be cut it is better to treat the stump than not.

Application of herbicide to the cut stumps must be conducted immediately after cutting, within 5-15 minutes of the cut with water soluble formulations, longer with oil mixtures, to ensure uptake of the chemical before the plant seals the cut area off. The mixture may be painted on with a paint brush or sprayed on using a spray bottle or backpack sprayer.

A mixture of 20% Garlon 4 plus 80% oil diluent, as for basal bark spraying (above), may be used. In this case the whole stump surface and sides to the ground line would be sprayed. Another option is to use Garlon 3A at 100%, treating only the outer 1/3 of the stump surface.

Be prepared to follow-up with a foliar application the next year to control any stump sprouts or root suckers which emerge. Other herbicides which have shown to be effective in stump treatment of ailanthus are the same as those listed above for hack and squirt or injection.

A potential biological control for ailanthus may lie in several fungal pathogens, (*Verticillium dahliae* and *Fusarium oxysporum*) that have been isolated from dead and dying ailanthus trees in New York and in southern and western Virginia.

SUGGESTED ALTERNATIVE PLANTS: Many lovely native trees and shrubs make excellent substitutes for Ailanthus and are readily available. Some examples for the eastern United States include deciduous shrubs such as staghorn sumac (*Rhus typhina*), smooth sumac (*Rhus glabra*), box elder (*Acer nigrum*), fringetree (*Chionanthus virginicus*), ash (*Fraxinus* spp.), and black walnut (*Juglans nigra*). Because U.S. native plants can become invasive outside their natural, historical ranges, be sure to use plant species native to the ecological region you live in. Check with your local native plant society for recommendations of species and sources of native plants.

White Poplar *Populus alba* L.

NATIVE RANGE: Central and southern Europe to western Siberia and central Asia
DESCRIPTION: White poplar, also known as silver-leaved or silverleaf poplar is a tall member of the willow family (Salicaceae) that, at maturity, may reach 70 feet or more in height and 2 feet in diameter. The smooth, greenish-white bark becomes dark and rough on older trees. Young green or brown twigs are coated with dense woolly hair, especially near the tip. A cross-section of the stem reveals a five-pointed, star-shaped pith. The 2 to 5-inch long leaves are oval to maple-leaf in shape with 3-5 broad teeth or lobes, and are dark green above and covered with dense white hair below. Male and female flowers are borne in catkins on separate trees and appear sometime in March and April. The small seeds are adorned with cottony fluff that is easily blown by the wind in late spring, and is a bane to many landscape maintenance workers.

ECOLOGICAL THREAT: White poplar outcompetes many native tree and shrub species in mostly sunny areas, such as forest edges and fields, and interferes with the normal progress of natural community succession. It is an especially strong competitor because it can grow in a variety of soils, produce large seed crops, and resprouts easily in response to damage. Dense stands of white poplar prevent other plants from coexisting by reducing the amount of sunlight, nutrients, water, and space available.

DISTRIBUTION IN THE UNITED STATES: White poplar is found in forty-three states throughout the contiguous U.S.

HABITAT IN THE UNITED STATES: White poplar seems to grow best in full sun habitats such as fields, forest edges, and wetland fringes.

BACKGROUND: White poplar was first introduced to North America in 1748 and has a long history in cultivation. It is chiefly planted as an ornamental for its attractive leaves of contrasting color (i.e., green above, white below). It has escaped and spread widely from many original planting sites. Because it is susceptible to a wide variety of pest insects and diseases, and is easily damaged by storms and wind, the ornamental value of white poplar is low.

BIOLOGY & SPREAD: Local spread of white poplar is primarily by vegetative means, through root suckers. Root suckers arise from adventitious buds on the extensive lateral root system. Large numbers of suckers from a single tree can quickly develop into a dense colony. Suckering can occur naturally or as a result of damage or other disturbance to the parent plant. Mature white poplar trees produce thousands of wind-dispersed seeds that may be carried long distances. However, seed germination of white poplar appears to be very low in the U.S.

CURRENT MANAGEMENT APPROACHES: White poplar can be controlled using a variety of physical and chemical controls. Removal of seedlings and young plants by hand will help prevent further spread or establishment. Plants should be pulled as soon as they are large enough to grasp. The entire root system, or as much of it as possible, should be removed to prevent resprout from fragments. Hand removal of plants is best achieved after a rain, when the soil is loose.

Trees of any size may be felled by cutting at ground level with power or manual saws. Because resprouts are common after cutting, this process may need to be repeated many times until the reserves of the tree are exhausted. Girdling, which kills the tree by severing tissues that conduct water and sugars, also may be effective for large trees, especially if accompanied by application of a systemic herbicide to the cut area.

A hatchet or saw is used to make a cut through the bark encircling the base of the tree, approximately six inches above the ground and deep into the bark. Girdling will kill the parent tree but may require follow-up cutting or treatment of sprouts with an herbicide.

Chemical control of white poplar seedlings and small trees has been achieved by applying a 2% solution of glyphosate (e.g., Roundup) or triclopyr (e.g., Garlon 3) and water plus a 0.5% non-ionic surfactant to the foliage until the leaves are thoroughly wet. Use of low pressure and a coarse spray with large droplet size will reduce spray drift and damage to non-target plants. **CAUTION:** Because glyphosate is a non-selective systemic herbicide, it may kill other grasses, broadleaf herbaceous and woody plants that it contacts. Triclopyr kills broadleaf (dicotyledonous) plants but causes little or no damage to grasses and is useful for areas where desirable grasses are to be maintained.

The cut stump herbicidal method should be considered when treating individual trees or where the presence of desirable species precludes the use of foliar herbicides.

Stump treatments can be made at any time of year as long as the ground is not frozen. After cutting the tree near ground level, a 25% solution of glyphosate or triclopyr and water is applied to the stump by spray bottle or brush, making sure to cover the outer 20% of the stump.

Basal bark herbicidal treatment is also effective throughout the year, as long as the ground is not frozen, and does not require cutting of the tree.

A mixture of 25% triclopyr in an ester formulation (e.g., Garlon 4) and 75% horticultural oil is applied to the bark in a wide band around the base of the tree to a height of 12-15 inches from the ground. Thorough wetting is necessary for good control; spray until run-off is just noticeable at the ground line, but not running off-site.

SUGGESTED ALTERNATIVE PLANTS: Hundreds of native tree species are available that can be used in place of white poplar. A few examples, for parts of the eastern U.S. only, include white oak (*Quercus alba*), red maple (*Acer rubrum*), American holly (*Ilex opaca*), persimmon (*Diospyros virginiana*), and sweetgum (*Liquidambar styraciflua*). Check with your local native plant society for further suggestions on trees native to your area and where you can purchase them.

USE PESTICIDES WISELY: ALWAYS READ THE ENTIRE PESTICIDE LABEL CAREFULLY, FOLLOW ALL MIXING AND APPLICATION INSTRUCTIONS AND WEAR ALL RECOMMENDED PERSONAL PROTECTIVE GEAR AND CLOTHING. CONTACT YOUR STATE DEPARTMENT OF AGRICULTURE FOR ANY ADDITIONAL PESTICIDE USE REQUIREMENTS, RESTRICTIONS OR RECOMMENDATIONS.

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Topic 6 Tree Section- Alien Plant Invaders
Answers at the rear of Glossary

Fill-in-the-blank

1. Elimination of _____requires diligence, due to its abundant seed production, high seed germination rate, and vegetative reproduction. Follow-up monitoring and treatment when needed should be an integral part of any serious ailanthus management program.

2. _____ can be controlled using a variety of mechanical and chemical controls. Hand pulling may be effective for young seedlings. Plants should be pulled as soon as they are large enough to grasp.

3. Because _____spreads by suckering, resprouts are common after cutting. Cutting should be considered an initial control measure that will require either repeated cutting of resprouts or an herbicidal treatment.

4. _____ can be controlled using a variety of mechanical and chemical controls. Trees can be cut at ground level with power or manual saws. Cutting is most effective when trees have begun to flower to prevent seed production. Because mimosa spreads by suckering, resprouts are common after treatment. Cutting is an initial control measure and will require either an herbicidal control or repeated cutting for resprouts.

5. No biological controls are currently available for management of_____. For new or small infestations, manual removal of Australian pine seedlings and saplings is recommended. For heavier infestations, application of a systemic type herbicide to bark, cut stumps, or foliage is likely to be the most effective management tool. Prescribed fire has also been used for large infestations in fire-tolerant communities.

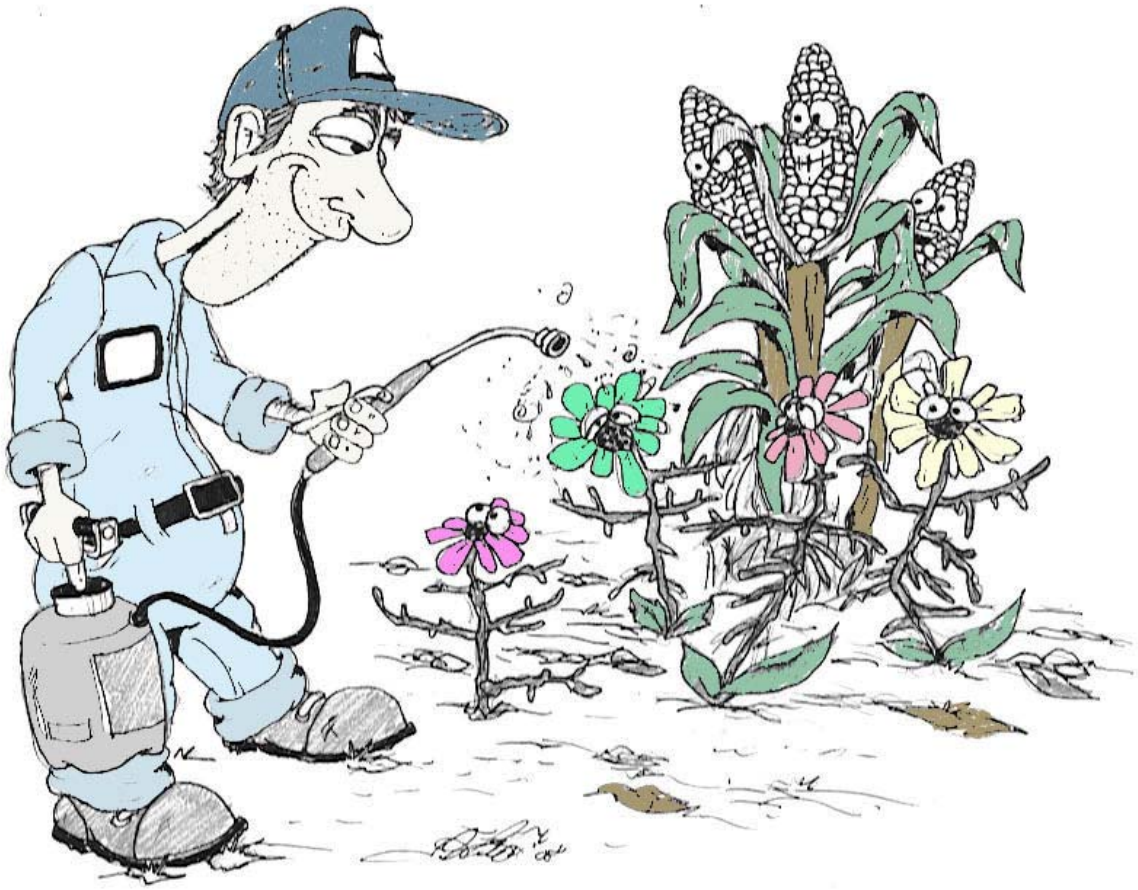
6. _____ is a prolific seed producer, and the brightly colored fruits are very attractive to birds which disperse it widely. Bird dispersal explains isolated island populations and seedlings under trees and telephone poles.

7. Chemical control of _____seedlings and small trees has been achieved by applying a 2% solution of glyphosate (e.g., Roundup) or triclopyr (e.g., Garlon 3) and water plus a 0.5% non-ionic surfactant to the foliage until the leaves are thoroughly wet. Use of low pressure and a coarse spray with large droplet size will reduce spray drift and damage to non-target plants.

8. Mechanical, physical and chemical methods are available for control of_____, also an invasive exotic plant. Prescribed fire is one method proposed for controlling buckthorn seedlings in fire-adapted natural areas, from late March to early May, most recently by Boudreau and Wilson.

9. _____appear vulnerable to fire, perhaps due to their poorly established root structure. Fire will top kill a mature plant, but resprouting does occur.

10. _____ spreads over sandy soil areas, creekbanks, and gullies. This can lead to a significant loss of prime grazing land. The seeds of castor oil contain ricin, a poison which is extremely toxic to livestock and humans. Leaves have a lesser amount of toxin.



Postemergence herbicides are used to kill weeds after the weed plants are up and growing. To be effective, most postemergence herbicides must be absorbed through the leaves; consequently, liquid sprays generally work better than dry, granular materials. However, granular formulations may be the most practical way for homeowners to apply these materials.

Topic 7 General Weed Management and Control Section

The terms listed below are used in this course to describe herbicide applications:

Active ingredient (ai) – The chemical in a herbicide formulation primarily responsible for its phytotoxicity and which is identified as the active ingredient on the product label.

Acid equivalent (ae) – Expresses the rate or quantity as the herbicidally active parent acid. For example, 2,4-D acid is formulated with either sodium, an amine, or an ester to make the active ingredient salt sold as a formulated product. The active acid equivalent per gallon of a widely used ester formulation is 3.8 lb ae/gal while the active ingredient is 6.0 lb ai/gal.

Band application – Herbicide applied to a narrow strip centered over the crop row.

Broadcast application – Herbicide applied over entire area.

Directed spray application – Herbicide applied to a band along the row that includes the base of crop plants and the weeds in the row. Spray is directed across the row from nozzles positioned near ground level on each side of the row. This type of application allows use of chemicals that will injure the crop plant if more than a small part of the plant is contacted by spray. Special units that guide from the ground or mount on cultivators must be used.

Drop-nozzle application – Herbicide applied by means of nozzles mounted on extensions below the spray boom to avoid spraying upper parts of the crop plant.

Formulation – Refers to the form in which a herbicide is purchased. Common forms are liquids, granules, and wettable powders which contain added ingredients to improve storage, mixing, or application characteristics of the herbicides.

Post-emergence application – Herbicide applied to the crop and weeds after they emerge.

Pre-emergence application – Herbicide applied after a crop is planted but before it or weeds emerge.

Pre-planting application – Herbicide applied before the crop is planted.

Rate – The amount of active ingredient or acid equivalent of an herbicide applied to the area treated, that is, on a broadcast basis.

Soil incorporation – Mechanical mixing of the herbicide with the soil. Chemicals may be incorporated 2 to 4 inches with a disk or rotary tiller, 1 to 2 inches with a harrow or rotary hoe, or slightly covered with planter attachments. The desired depth of incorporation depends on characteristics of the chemical being used.

Camphor Weed *Heterotheca latifolia*

Just break a leaf and you can easily recognize the smell of camphor.

DOWNY BROME

Weed Control Management

Effective weed control usually results from a combination of cultural, mechanical, and chemical practices. The ideal combination for each field will depend on a number of considerations including: 1) the crop being grown, 2) the kinds of weeds, 3) the seriousness of the weed infestation, 4) the soil type, 5) the cropping system, and 6) the availability of time and labor.

Preventive weed control is the least expensive and the only foolproof method to stop invasions of weeds. If we don't have it now, let's not plant it. When purchasing plants or seeds make sure you know what you're buying. This is extremely important when purchasing plants or seeds by mail order or through the Internet. Be particularly wary of seed mixtures--completely read the product label and make sure you are familiar with all the species in the mix. Go native to make sure you aren't introducing current or potential noxious weeds. Reputable nurseries will be able to assist you in selecting native species of plants for your lawn, landscape, or garden. Master Gardeners are another source of information on the best species of plants to select for landscape or garden.

It is also important to prevent the accidental introduction of new invasive species. Make sure that compost, mulch, sod, fill soil, or any other amendment you use is free of weeds. Use a local source for these products.

Feed your livestock weed-free feed. Sometimes this is not possible during animal transport or for other reasons. Be certain to allow time for the animals to "clean out" the weed infested feed before putting them out on pasture or rangeland.

The same is true of newly added cattle, horses, or other animals. Make sure you compost manure and bedding from the period during and just after feeding suspect feed. Check boats and off-road vehicles before leaving the area where you have used them. Weeds can be carried easily in water or mud so wash the vehicles as soon as possible following use.

Even if preventative steps are taken, infestations can still occur. Be constantly on the watch for areas where you suddenly notice a new flush of vegetation. Early detection is critical to complete eradication of the weed.

Control efforts can easily be intensified and eradication a realistic goal. Weeds can be spread by animals or birds, but new infestations are most commonly due to human activities. Look for new species of weeds in areas where human activity is most common or along waterways.

What do you do once the infestation has been identified?

- Mark the perimeter of the area to delineate the infestation and determine if the infestation is increasing or decreasing once control measures are applied.
- Limit activity to and from the area to make sure seeds, roots, and other parts aren't spread.
- Try to determine how the weed was introduced. If it appears due to logging, construction, or other activities, scout similar sites in the area.
- Check horse or recreational vehicle trails in the area to determine spread.
- Check upstream and downstream if the infestation occurs along water ways.
- Select the appropriate control measures and apply them aggressively.
- Monitor the area constantly to determine the effectiveness of the control measure. Seeds can lay dormant in the soil for 10 years or longer, continue monitoring for years after you've seen the last plant in the area.

Weed Prevention Steps

Key- Avoid weed establishment; eliminate individual survivors.

- Identify and map weed infestations; keep records over years.
- Recognize and eliminate new weeds before they multiply and establish.
- Employ sanitary procedures; prevent weed spread.
- Clean equipment between sites or infestations.
- Examine nursery plants, seed, and imported soil or media.
- Screen irrigation water where weed seed contaminates surface water transported in canals and rivers or stored in lakes or ponds.
- Control weeds and seed sources around the field or site.
- Establish county and state weed laws and noxious weed control programs.

When applying control measures, start with the most basic mechanical control. Dig out the plants if possible. Burn or compost the removed vegetation on site to prevent spreading them. Mowing can be effective, but mowing promotes low growth and low seed height which can't be prevented by mowing a second time. Also, equipment must be completely cleaned of vegetation and seed before removing from the site to prevent spreading the infestation. Mechanical control is expensive, but most effective and won't interfere with reestablishing desired vegetation on the site.

Mechanical Control

A combination of mechanical and chemical controls can be very effective on woody invaders like trees or shrubs. The woody plant can be cut with hand ax or saw and the stump wiped with 2,4-D, Roundup™, or some other herbicide. It is important to apply the herbicide to the stump immediately after cutting. A delay of even a few minutes will reduce efficacy of the herbicide.

Normally, biological control of newly invasive species is not practical and should not be considered. Identifying and developing biological controls can take years, and small infestations often can't sustain on the few plants present during the initial infestation. Thus, biological control, while effective on widespread infestation, is not a consideration in eradicating a species during the initial phases of an infestation.

Cultural Control is necessary following mechanical or chemical control. Digging and chopping cause soil disturbance and desired plants need to be reestablished before the invader can get a foothold. The same is true of chemical control, the desired vegetation must be reestablished. Moreover, you must remember that the invader was able to gain a toehold under the management regime that had been in place on that land. Consider plant species, fertilization, and other cultural aspects of weed control.

Mechanical Summary

Weed debris turned under; annual weeds controlled; perennial weeds suppressed if this practice is repeated every 10 to 14 days.

Cultural Practices

Cultural practices that are optimum for crop growth should be followed. These practices include: adequate fertility, optimum stands and row width, and proper seeding date. Tillage operations, if used, should be timed to destroy weeds. Tilling the soil immediately before planting will kill weeds that have germinated, thus giving the crop a competitive advantage and often improving weed control from chemicals that do not control weeds that have germinated.

Early cultivations when weeds are small are most effective. Use a rotary hoe, harrow, or cultivator as soon as weeds begin emerging and are in the "white stage," even if herbicides have been applied. Set cultivators for shallow operation to avoid crop root pruning and to reduce the number of weed seeds brought to the surface. Throw enough soil into the row to cover small weeds. Shallow cultivation should be repeated as necessary to control newly germinated weeds.

Mowing is an effective weed control practice in perennial forage crops and non-cropland areas. To be effective, mowing must be done before seeds are formed which means you must mow by the time weeds are in the bud stage or just beginning to bloom. Earlier mowing will reduce weed competition and improve crop yield more than later cutting.

Cultural Summary *Integrate numerous components to minimize impact of weeds.*
1. Select manageable fields (identify weeds and choose crop according to feasibility of weed management strategies; e.g., avoid planting onions into perennial weeds).
2. Rotate crops (disrupt weed life cycles or suppress weeds in competitive crop followed by planting a noncompetitive crop).
3. Plant winter cover or competitive fallow crops in rotation to improve soils and crop management (specific cultivars are being evaluated).
4. Consider legumes to supplement nitrogen requirements.
5. Consider specific varieties of cereals with natural plant toxins (allelopathy); vegetation must remain uniform on soil surface; either perennial or large-seeded crops can be planted through undisturbed mulch.
6. Consider crops or cultivars that winter kill after vigorous growth during fall to avoid springtime controls.
7. Alter planting dates (plant for maximum growth or delay planting to control first weed flush).
8. Transplant slow-growing crops.
9. Band or spot fertilizer beside plant or seed (reduces availability to surface-germinating weeds).
10. Time additional side-dressings for maximum crop growth or to minimize weeds.
11. Develop crop canopy that shades weeds, suppresses weed germination.
12. Select crops or varieties that form canopy quickly.
13. Space plants in equidistant (triangular) arrangements and vary density depending on crop management constraints or harvest requirements (e.g., product quality).
14. Interplant crops in space and time (consider mechanical limitations in commercial plantings).
15. Combine broadleaf and taller, narrowleaf crops (corn or beans with pumpkins).
16. Relay plantings or harvest short-duration crops within longer maturing crops (bush beans with corn; cucumbers with peppers; tree crops with vegetables).
17. Manage appropriate living mulch (grass or legume) between perennial crop rows.
Improve pasture management by reseeding and/or fertilizing with or without control measures to reduce weed infestation (weeds often are a symptom of poor management).

Apply Mulch, Black Plastic or Geo-textiles
Organic materials: Straw (may reduce available N when decomposing; often infested with weed seed). Sawdust (avoid vertebrate pests by maintaining mulch-free circle around tree; perennial weeds become a serious problem).
Bark mulch: Newspapers (during emergence, rhizomes of some perennial weeds become disoriented when penetrating 6 to 16 layers of overlapped newspaper).
Plastic: Black excludes light, controls most annual weeds.
Clear plastic acts like greenhouse; poor weed control. New wavelength-selective plastics for pest management (research is progressing).
Geo-textiles (available at ag and garden supply stores): **Spunbonded fabrics** (nonwoven): lightweight, extruded polypropylene fibers; requires mulch cover due to moderate UV light sensitivity; weed roots and rhizomes can penetrate fabric unless removed before establishment; cheapest option.
Woven fabrics: moderate-weight polypropylene fibers woven into a mat; can be used without mulch cover due to UV light stability; weed roots and rhizomes can penetrate fabric although tightness of weave can prevent some weeds; moderate cost.
Laminates: highly porous, dense poly film bonded to capillary fibers with a pressed, nonwoven bottom layer. Surface is slick and causes rapid wetting and drying to prevent weed establishment except for perennial rhizomes which can penetrate the laminate; most expensive geo-fabric.
Solarization: Thin plastic secured tightly over loose, moist soil for 10 to 12 weeks will suppress weed infestations and other pests during hot season.

Preventive Weed Control Measures

Prevention is the most essential aspect of weed management. Once a noxious weed infestation becomes established, any increase in size and density creates increasingly more expensive management efforts. Awareness of weed seed sources and plant identification is a must. Feel free to call the Weed District office or county agent for help with identification or to set up a site visit, and recognize:

- ✓ Weed seed can be spread from neighboring properties, adjacent road rights-of-way and trails. Direct sources are often livestock, manure, seed, hay, vehicles and equipment.
- ✓ Disturbed ground is most vulnerable to weed invasion; new roads, pipelines and other sites where competitive vegetation has been removed. With no restoration (see cultural control) weeds will likely appear.
- ✓ Early detection and rapid response saves time and money. Aggressive management action on small, newly established infestations can result in eradication. "An ounce of prevention is worth a pound of cure."

Cultural Control

Cultural control, the establishment of competitive and desired vegetation, prevents or slows down invasion by weedy species and is a key component of successful weed management. Weeds are typically opportunistic and readily invade disturbed sites.

Impacts from road construction, intensive livestock grazing, densely populated prairie dog colonies and other disturbances that damage or remove desirable and competitive vegetation create sites for noxious weed invasion. Controlling weeds on such sites can be futile without vegetative restoration, as weeds will readily re-invade the disturbed area.

Establishment of grassland or pasture can be challenging. Success often depends on proper species selection suitable for a particular soil type, moisture regime and growing season. Other factors such as soil compaction, seeding depth, time of year, and weed control during establishment can be critical to success.

Chemical Methods

Herbicides are another weed control aid that some gardeners employ. Gardeners should be aware that no single herbicide will do the entire job of controlling weeds in all vegetable crops. There is also a problem of applying relatively small amounts of the herbicide evenly to the garden surface. Miscalculation of rates or miscalibration of application equipment can cause some areas of the garden to get too much or too little of the herbicide. Under-application will result in poor weed control while over-application will result in damaged plants.

For small areas, several chemical manufacturers (e.g. Ortho, Scott, Southern States, Security, and others) sell a variety of herbicides in small quantities which are ideal for this job. These chemicals are usually formulated to make them more convenient and easier for the homeowner to apply. For larger areas, several products can be purchased can be purchased at farm chemical retail stores.

For all-purpose weed control when no crop is present (either in the fall, later winter, or early spring), use Roundup (Ortho's Kleenup). This material, applied over the top of weeds, will kill all weeds. Do not use this material when crops are present or serious injury will occur.

To control germinating weed seedlings before the crop emerges, only one major herbicide is available to choose from. This material is trifluralin (Treflan). The trade name (listed in parentheses) is the more commonly marketed forms of this herbicide. However, this herbicide may be marketed using other trade names and the buyer should read the ingredients list to be sure that the common name of the herbicide, which is listed before the trade name, appears on the label.

Weed control chemicals are available as concentrated liquids, (2 to 8 lb/gal) which need to be mixed with water before applying; as wettable powders which are from 50 to 100% active ingredient and need to be dispersed in water for uniform application, or as granules which are from 1 to 10% active ingredient and which are applied dry with granular applicators. See the label for all instructions on labeled crops and timings.

Emerged grasses can be controlled using hand removal, cultivation (see previous discussion) or sethoxydim (Poast) herbicide. It is usually effective when applied to grasses that are no larger than 4 inches tall. Consult the chart at the end of this section and the herbicide label for specifics on use, labeled crops and timings. Never exceed the recommended rate, as severe plant injury may occur.
Before selecting an herbicide, you must know the weeds you have and whether they are annual or perennial. You also need to consider their proximity to desirable plants. For broad-leaved perennial weeds, such as dandelion, plantain and perennial chickweed, products containing 2,4-D can be very effective, especially in the lawn. Take care to avoid drift if you have trees or shrubs in or adjacent to the lawns. Spot treat problem weeds rather than broadcast applications to the entire lawn.

Some broad-leaved weed killers also contain a chemical called dicamba (banvel). This product is useful in managing the tough-to-control weeds such as bindweed, thistle and oxalis. Because it can leach into the root zones of trees and shrubs, this product should be used sparingly as a spot treatment, wetting only the foliage of the weeds.

In vegetable gardens, as well as shrub borders, avoid use of broad-leaved weed killers containing 2,4-D and/or dicamba. The fumes alone can injure your plants. It is best to clean, cultivate and hand pull existing weeds, then apply a pre-emergent herbicide (weed preventer) to control any weeds that would come up from seed. Several products on the market are labeled specifically for this purpose. They usually contain dachtal or surflan. Be sure to follow all label directions to avoid injury to your vegetables.

If you have weedy areas along fences, around buildings or in gravel or other mulched areas, spot treat with glyphosate (sold as Roundup or Kleenup). Avoid applications with a fine mist-type sprayer, as even small amounts can injure non-target plants. More than one application may be needed on bindweed and thistle. Glyphosate works best when weeds are actively growing with plenty of foliage.

Do not be tempted to control weeds in your landscape with "total vegetation control chemicals" such as Triox, Pramitol and Spike. By state law, effective Jan. 1, these and similar products can only be used by certified commercial applicators. These are soil sterilants and can migrate to tree roots, shrubs and other plants with long-lasting damage. Damage can result even if you follow the label carefully. These products also can harm your neighbors' trees if their roots extend into the treated area of your property.

When using herbicides, always read the label thoroughly and follow directions carefully. The misuse of an herbicide can lead to disappointment and to long-range problems in your garden.

The best approach is to use selective applications of herbicides to target exotic plants while avoiding or minimizing application to desirable plants. Selective methods (see details in later section) are:
1. Directed foliar sprays: herbicide-water sprays aimed at plant foliage to cover all leaves to the point of run off and usually applied with a backpack sprayer (use low pressure, drift retardants, and spray shields to avoid drift).
2. Stem injection (including hack-and-squirt): herbicide concentrate or herbicide-water mixtures applied into incisions spaced around woody stems made by an ax, hatchet, machete, brush ax, or tree injector.

3. Girdle-treat: herbicide concentrate or herbicide-water mixtures applied to an encircling band of removed bark around woody stems made by a cutting tool and applied with a spray bottle, wick, or paint brush.
4. Cut-treat: herbicide concentrate or herbicide water mixture applied to freshly cut stumps (outer circumference) or stems (entire top surface) with a backpack sprayer, spray bottle, wick, or paint brush.
5. Basal sprays: herbicide-oil-penetrant mixture sprayed or daubed onto the lower portion of woody stems usually applied with a backpack sprayer or wick applicator.
6. Soil spots: application of Velpar L herbicide as metered amounts to the soil surface around target woody stems or in a grid pattern for treating many stems in an area; usually applied with a spotgun or with a backpack sprayer equipped with a straight-stream nozzle.

To treat extensive inaccessible infestations, it may be necessary to use broadcast treatments of herbicide sprays or pellets by helicopter- or tractor-mounted application systems.

To be successful with herbicide treatments:
1. The most effective herbicide for the species should be used.
2. Applied using correct methods prescribed on the label.
3. Applied during an optimum time period for maximum herbicide effectiveness.
4. Follow and adhere to all label prohibitions, precautions, and Best Management Practices during herbicide transport, storage, mixing, and application.

As far as timing, foliar applied herbicides are often most effective in late-summer to early fall and not later than a month before expected frost.
Mainly herbicides registered by the Environmental Protection Agency for forestry use and noncrop lands in the Southeast will be discussed here. Herbicides in other "land use areas" (such as right-of-ways, pastures and rangelands, etc.) may be just as effective, or even contain the same active ingredient of those mentioned.

The herbicides that will be recommended by trade name (and common name) are:
Foliar active herbicides
Foliar and soil active herbicides
Glyphosate herbicides (glyphosate)
Arsenal AC (imazapyr) such as: Accord Concentrate
Escort (metsulfuron)
Glyphosate
Pathfinder II (triclopyr)
Gly-Flo Herbicide
Pathway (2,4-D + picloram)
Garlon 3A (triclopyr)
Plateau (imazapic)
Garlon 4 (triclopyr)
Tordon 101 (2,4-D + picloram)
Tordon K (picloram)
Transline (clopyralid)
Vanquish (dicamba)
Velpar L (hexazinone)

Because exotic pest plants are usually difficult to control it is often necessary to use herbicides that have both soil and foliar activity to be most effective with the least number of applications. When applying herbicides with soil activity, it should be recognized that damage to desirable plants might occur when their roots are present within the treatment zone, or when herbicides may move downhill following heavy rainfall to untreated areas. Garlon herbicides are mainly foliar active but have some soil activity at high rates and when mixed with oils.

Garlon 4 and Vanquish have potential to volatilize at high temperatures and their residues can move by air currents to impact surrounding plants. Thus, applications should be avoided on days when temperatures exceed 80oF. If possible, forgo applications during periods of severe drought as herbicide effectiveness can be greatly reduced during these times. Also, applications should not be make when rainfall is anticipated within two days, unless soil activation is needed.

When possible, use selective herbicides that target specific species of alien plants and minimize damage to surrounding desirable plants even though they receive herbicide contact, such as Transline that controls mainly legumes (e.g., peas and beans) and composites (e.g., asters, sunflowers, goldenrods, etc.). Also, damage to desirable cohorts can be minimized by making applications when desirable plants are dormant (e.g., basal sprays in late winter). For example, evergreen or semi-evergreen exotic plants can be treated when surrounding non-evergreen native plants have entered dormancy. Unfortunately, desirable woody plants can be damaged through transfer of herbicides by root grafts and root exudates when applying stem injection, girdle-treat and cut stump treatments to adjoining exotic woody plants, or when soil-active herbicides wash off treated stems. Damage to surrounding native plants can be minimized with care and forethought during planning and enactment of application.

Read and thoroughly understand the herbicide label and its prohibitions before and during use. Many herbicides require the addition of a non-ionic surfactant to the spray tank to be effective. Other important points are to always use clean water when required in a herbicide mixture and mix spray solutions thoroughly before applying. Mixing should not be done in the sprayer but in a bucket with a stirring stick—stirring for a minute or more—before transferring to the sprayer. When changing from a water-based mix to an oil-based mix in a backpack sprayer, always remember to thoroughly evacuate the water from the pump and run a small amount of oil through the pumping system before filling with the oil-based mix, or a white sludge will clog the sprayer. And, always wear your personal protective equipment prescribed on the label and in supplementary materials.

Other Treatments for an Integrated Approach

Overgrazing is a way to reduce the vigor of palatable invasive plants like kudzu, but this rarely yields eradication and may spread seeds (now occurring with tropical soda apple). Mechanical treatments and prescribed burning can assist eradication measures, but are limited in effectiveness. Prescribed burning does not control root-crowns or rhizomes of perennial plants and usually only kills small aboveground shoots, providing only temporary aboveground control. In a similar way, chainsaw felling or brush mowing woody exotic plants and mowing vines and herbs, without killing roots, remove only aboveground plant parts. Mechanical root raking and disking can actually spread or aggravate a problem when dealing with plants having runners by chopping these into resprouting segments. However, the use of root raking, piling, brush mowing, or burning may be the only way to start controlling dense infestations of multiple woody exotics. Small infestations may also be handled by hand pulling, grubbing with a stout hoe, or by using the newly introduced shrub-pulling devices. Hand pulling or grubbing may be the quickest and easiest way to halt invaders when first spotted so as to stop them from gaining a foothold.

Although ineffective by themselves to achieve eradication, both mechanical and burning treatments can give added kill of herbicide-weakened plants and have a place in an integrated pest management program. The stumps and stems of exotic trees, shrubs, and bamboos that are felled can be treated with herbicides immediately after cutting to kill roots. Resprouts of trees, shrubs, and vines that are top killed by burning can be more easily treated with foliar sprays, often the most cost-effective way to use herbicides. Herbicide applications following burning or disking should be delayed to permit adequate resprouting of target plants for maximum herbicide uptake and effectiveness. Prescribed burning can also kill or stimulate seed germination of troublesome plants permitting effective herbicide control of germinants. Burning can also prepare the site for effective herbicide applications by clearing debris and revealing application hazards, such as old wells and pits. Disking and root raking, if applied correctly, can dislodge herbicide-damaged woody roots and large runners, leaving them to dry and rot.

Mechanical Weed Control

Mechanical control consists of methods that kill or suppress weeds through physical disruption. Such methods include pulling, digging, disking, plowing and mowing. Success of various mechanical control methods is dependent on the life cycle of the target weed species.

- ✓ Hand pulling and digging are effective on annual and biennial species such as kochia, musk thistle, and diffuse knapweed. It is important to remove the upper 2-3 inches of taproot to prevent re-growth. Hand pulling or digging a perennial weed such as leafy spurge can be a futile effort unless one has the time necessary to diligently dig or pull re-growth over several seasons.
- ✓ Shallow tillage with a disk or sweep is effective for controlling annual species such as cheatgrass or kochia, but can actually be counterproductive if trying to control perennial weeds such as Canada thistle, field bindweed, leafy spurge or Russian knapweed. Perennial root systems often have meristematic buds that can set roots and produce a new plant from root segments deposited on the soil surface. Shallow tillage of perennial weeds can result in a larger, denser and more uniform infestation than the initial patch.
- ✓ Moldboard plowing (complete turnover of the top 10-12 inches of soil) disrupts underground root systems and buries seed from the surface to a depth too deep to germinate. This type of tillage is seldom feasible to practice on a regular basis.
- ✓ Mowing is a suppression measure that can prevent or decrease seed head production. Mowed weeds will re-grow and set seed from a reduced height so a combined control method is necessary to be effective. Mowing causes perennial plants to weaken when forced to send up carbohydrates from underground root reserves to nourish re-growth. So mowing a perennial weed such as Canada thistle a couple of times during the summer can significantly weaken the plants, and when combined with a fall herbicide application, provides excellent control.

Several implements can be used to cultivate weeds. Push plows, also called push cultivators, are inexpensive and also very effective in killing small weeds. The large wheel versions are usually easiest to push. For large weeds, a garden tiller or small tractor is most effective. Regardless of the implement, cultivate no deeper than 2 inches deep to prevent root damage to vegetable plants. Cultivators should normally be adjusted to throw soil around the base of crop plants and over any emerged weeds that are present in the row. Row spacing can be adjusted to allow close mowing near the soil surface to control weeds. Self-propelled rotary or sicklebar mowers and/or mowers with large rear wheels are easiest to maneuver. Weedeaters fitted with plastic string can also be used to cut weeds near the soil surface. Extreme care should be used for crop and personal safety. See manufacture's warnings prior to operating all equipment.

Mechanical Weed Control: Mechanical weed control involves the physical destruction of a weed. Techniques involve hand pulling and hand hoeing which are practical for small infestations. Mowing is often used; but by far, the most common practice of mechanical control includes tillage. Advantages of tillage include:

- • Elimination of weed debris
- • Control of annual weeds
- • Suppression of perennial weeds
- • Tillage methods include plowing, rototilling, disking, and harrowing. Weed control implements include sweeps, rolling cultivators, finger weeders, push hoes, rotary hoes, etc.

What You Can Do

In order to prevent the introduction or spread of invasive alien plants into natural areas, and to help restore our native flora and fauna, you can:

- ✓ Avoid disturbance to natural areas, including clearing of native vegetation, planting of non-native plants and dumping of yard wastes.
- ✓ Control exotic invasive plants in your landscape either by removing them entirely or by managing them to prevent their spread outside your property. This may include pruning to

prevent flowering and seed dispersal or cutting, mowing or herbicide use to prevent vegetative spread.

- ✓ Discuss your concerns about invasive exotic plants with nurseries and garden shops and ask them not to sell these species. Provide them with printed material (such as this) explaining the problem to read later. Ask for non-invading alternatives instead.
- ✓ Do not purchase or use invasive exotic species in your landscaping or for land restoration or erosion control projects.
- ✓ For landscaping, use plants that are native to your local region as much as possible or those that are not known to be invasive.
- ✓ Know your plants. If you are unsure of the identification of a plant, take a sample to a university, arboretum, department of agriculture office, local nature center, or native plant society for assistance. Find out if it is known or thought to have invasive tendencies. If the exotic plant is closely related to an invasive species, it is likely to have similar tendencies. To be on the safe side, if you don't know it, don't grow it.
- ✓ Notify land managers of invasive exotic plant occurrences.
- ✓ Offer to assist in exotic plant removal projects.
- ✓ Work with your local government to encourage the use of native plants in their urban and suburban landscapes. Provide them with lists of attractive, non-invasive locally native alternatives that are naturally hardier, pest-resistant, and provide more nutritious food for wildlife than cultivated plants.

Other Cultural Methods of Weed Control

Flaming is a technique that can be useful but it requires a physical difference or separation between crops and weeds, or crop protection with a hooded row cover or protein foaming agents. Proper water management, such as the use of drip irrigation or uniform irrigation, can eliminate certain weeds. Stale seedbeds involve a delay in planting after seedbed preparation to control the first flush of weeds before seeding.

Biological Weed Control

Biological control involves the use of natural enemies, such as predators, parasitoids, competitors, or pathogens to control pest insects, weeds, or diseases to levels lower than they would otherwise be. There are three main methods of biological control: conservation, introduction, or augmentation. Human activities can greatly influence the extent to which natural enemies are able to suppress pests.

The goal of biological control is not eradication, but the use of living agents to suppress vigor and spread of weeds. Such agents can be insects, bacteria, fungi, or grazing animals such as sheep, goats, cattle or horses. Grazing produces results similar to mowing, and bacteria and fungi are seldom available for noxious weed management. Biological control is most commonly thought of as 'insect biocontrol'.

USDA-APHIS (United States Department of Agriculture-Animal and Plant Health Inspection Service), is the federal agency responsible for authorizing the screening and importation of biocontrol insects. APHIS conducts intensive multi-year screening programs assuring an insect agent's host specificity (feeds only on target weed species, not other plants) prior to approval for release.

Biological weed control through insect/plant interactions is an important component of the County's weed management program. Insect agents, proven to be effective, are utilized in cases where eradication is impractical due to the vastness or inaccessibility of an infestation, and where other methods of management are not feasible. Insect agents typically require 3-5 years for establishment and can limit the spread and density of target weed species by feeding on leaves, stems, roots and/or seed heads.

One must realize that eradication of a weed cannot be attained through insect biocontrol. The most effective scenario is a weed infestation reduced to a 'tolerable level', a level where the insect agents are significantly limiting distribution and abundance of the target weed species and the weed density is no longer considered detrimental to the desired plant community. Some biocontrol insects proven to be successful are:

- ✓ Bindweed mites - field bindweed
- ✓ Flea beetles - leafy spurge
- ✓ Mecinus janthinus - dalmatian toadflax
- ✓ Larinus minutus and Cyphocleonus achates - diffuse knapweed

Conservation Biological Control is defined as any biological control practice designed to protect and maintain populations of existing natural enemies. This approach is particularly useful in agroecosystems where management practices such as cultivation, pesticide applications, and harvest disrupt the life cycle of the beneficial organisms. Introduction or

Classical Biological Control refers to the importation of foreign natural enemies to control previously introduced, or native, pests.

Augmentation Biological Control involves control practices intended to increase the number or effectiveness of existing natural enemies. This approach is commonly used in cases where natural enemies are missing (greenhouses) or late to arrive at new plantings (some row crops), or simply too scarce to provide control.

Many of our worst weeds originated in foreign countries and biological control practices can help us to maintain them below threshold levels. These newly introduced plants, free from the natural enemies found in their homelands, gained a competitive advantage over native plants. Once they are out of control, other methods of weed management are usually not economical or physically possible. The need for a method of weed reduction that was economical, self-sustaining, and environmentally safe provides opportunities for biological control. There are several well-documented successes of biological control: St. Johnswort (Klamathweed in California), tansy ragwort in Oregon, and rush skeletonweed in the Pacific Northwest.

Biological control is a slow process, and its efficacy is highly variable. It usually takes several years for a biological control agent to become established and control a weed. Biological control agents impact weeds in two ways: directly and indirectly. Direct impact destroys vital plant tissues and functions. Indirect impact increases stress on the weeds, which may reduce their ability to compete with desirable plants.

Thus, it is very useful to integrate biological control with other weed management practices. For example, once weeds are weakened by Biological Control Agents, competitive plantings may be used to outcompete the weeds.

The goal of a biological control program is not to eradicate a pest, but to maintain it below an acceptable threshold level. When using BCAs, a residual level of the weed populations must be expected since the survival of the agents is dependent on the density of their host weeds.
After populations of the host weeds decrease, populations of BCAs will correspondingly decrease. This is a natural cycle and should be expected. The BCAs released in the U.S. have been thoroughly tested to ensure they are host-specific. This is an expensive and time-consuming task that must be done before the agents are allowed to be introduced. An extensive assessment of BCAs prior to their release secures they will not switch to crops, native flora, and endangered plant species.

Biological control of certain weeds may not work in your area, even though an insect may be very effective in another area. Climate variations such as cold winters, and plant biotype differences may account for some of the failures that have occurred in the past. To ensure maximum success, trained personnel must supervise biological control programs. Biological control agents are living entities and require specific conditions to survive.

As with any other weed management method, biological control has benefits and disadvantages. The benefits include: reduction of herbicide residues in the environment, host specificity on target weeds, long-term self-perpetuating control, low cost per acre, searching ability to locate hosts, synchronization of agents to life cycles of hosts, and unlikelihood that hosts will develop resistance to agents. Some of the disadvantages of biological control include: the limited availability of agents from their native homelands, the dependence of control on plant density, the slow rate at which control occurs, biotype matching, and host specificity when host populations are low.

General Principles to Reduce the Impact of Invasive Plants

1. Learn to identify invasive plants and incorporate their management into any land-use plan.

2. Prevent introduction of invasive plants to uninfested sites: This critical component is one of the most cost-effective methods of management.

3. Contain and treat new invasive plants or those not yet well established: Controlling small infestations is more effective and economical than trying to control well-established, rapidly spreading infestations.

4. Minimize transport of invasive plants from infested to uninfested areas: Cleaning vehicles and equipment is the most effective method of prevention.

5. Minimize soil disturbance: Invasive plants often prefer disturbed ground, don't disturb soil unless it is necessary.

6. Maintain desirable species: Establishing and maintaining competitive, desirable plants along roadsides and disturbed areas prevents or slows establishment of invasive plants.

This course contains EPA's federal rule requirements. Please be aware that each state implements pesticide regulations that may be more stringent than EPA's regulations and these frequently are changed. Check with your state environmental/pesticide agency for more information.

Reducing Weed Control Costs

There are many possibilities for reducing weed control costs while still attaining good weed control. Wise selection of weed control practices and herbicides to fit specific field situations is the key. Identify your weeds and develop an effective, low cost control program that is suitable for the crop you plan to grow. Using band applications of herbicides in row crops, supplemented with cultivation, may save you money.

Reducing herbicide rates below those recommended increases the possibility of costly weed control failure. On the other hand, applying herbicides at greater than recommended rates adds unnecessarily to your weed control costs and may result in crop injury or herbicide carryover. Applying herbicides at the proper time and rate with a carefully calibrated applicator provides the best return on your herbicide investment.

Herbicide Mixtures

Herbicide mixtures are used to overcome limitations of single chemicals. Certain mixtures may:
(1) control more kinds of weeds,
(2) give more consistent performance with variable soils and weather conditions,
(3) lessen soil residue problems,
(4) increase persistence enough to give full-season weed control, or
(5) reduce crop injury.

Only those mixtures that have been field tested under local conditions should be used. Use of some mixtures may result in poor weed control or crop injury. Growers or applicators may be responsible for chemical residues in crops, crop injury or lack of weed control resulting from use of unlabeled mixtures.

Safety Precautions

Always follow the precautions and use restrictions on the label carefully to help protect the operator, avoid crop injury, and prevent harmful residues in food and feed crops. Use herbicides only on crops specified on the label. Use only the recommended amount of herbicide; applying too much of a herbicide may damage the crop, may be unwise if the crop is to be used for food or feed, and is costly. Apply herbicides only at times specified on the label; observe the recommended intervals between treatments and pasturing or harvesting of crops. Wear goggles, rubber gloves, and other protective clothing as recommended on the label. Prevent drift onto nearby susceptible plants. Return larger quantities of unused herbicides in unopened containers to the manufacturer or store them properly until used. Dispose of empty containers in a safe manner:

- Triple rinse container thoroughly with water and use the rinse water in the sprayer.
- Bury small and decomposable containers in approved and supervised sanitary landfills.
- Send empty metal pesticide containers of 15 gallon capacity or more back to the manufacturer or to professional drum reconditioners.
- Observe special label instructions relating to disposal.

Groundwater and Surface Water Contamination

The potential for ground and surface water pollution with pesticides is a growing concern. Good land stewardship dictates that herbicide characteristics must be assessed in relation to their ground or surface water pollution potential, in addition to choosing the most effective and economical weed control. Growing public concern and increasing frequency of detections of minute levels of pesticides in groundwater will result in regulatory action if corrective measures are not taken. Atrazine is the most commonly detected herbicide in well monitoring studies. Sink-holes and shallow soil over porous, fractured limestone bedrock poses a real problem for managing certain herbicides such as atrazine in the karst area. The same situation also exists where permeable sands over shallow water tables occur.

Alternatives to atrazine should be considered in these areas to reduce pollution concerns.

Also, other herbicides have ground or surface water advisory statements on their labels. Use these compounds in sensitive areas only after assessing site specific pollution potential.

The levels of pesticides being detected in groundwater are generally in the parts per billion (ppb) range and are below current health advisory levels considered safe for drinking water. These levels often represent less than 1/1000th of the amount applied to the field, alluding to the difficulty in managing pesticide pollution. Point source concerns are often suspect if levels in a well over a few ppb are detected. Point source problems are those directly attributable to a confined area, event, or site such as mixing or manufacturing sites. Point source contamination may be responsible for a large portion of pesticide detections in wells in some areas of the state. They are relatively easy to correct. Point source problems can be reduced by the following:

- Mix chemicals in the field using a 'water only' nurse tank thereby keeping pesticides away from wells and water sources.
- If chemicals must be mixed at the well site, use hoses to maintain at least a 150 ft. buffer from the well to the spray tank, 100 ft. buffer with safeguards, or 50 ft. with safeguards and a roof present.
- Keep filling hoses out of the spray tank, use check valves, and Do Not leave tanks unattended while filling to avoid backsiphoning or overflow.
- Never dump rinsate or concentrated product in a localized area. Dispose of rinsate by applying to a labeled crop site.
- Triple rinse herbicide containers before disposal or return.
- Properly construct, grout, and case new well construction. Properly cap and seal abandoned wells.

Sphaeralcea ambigua

*The desert mallow, globe mallow, "**sore eye poppy**," Sphaeralcea ambigua. The sore-eye name arose because the hairs on the plants are irritating to the eyes. They are also irritating to the skin of susceptible persons. This species is probably the most common mallow in the foothills area. However, there are many species of mallow which can be recognized by their flowers. Cotton is the most notable member of the mallow family. Okra is an edible mallow. Hibiscus and hollyhock are well known garden mallows. The sphaeralcea species are generally perennials, more or less woody at the base forming small bushes. The hairs of the leaves and stems are stellate or having radiating arms like a star. Both the shape of the leaves and the color of the flowers are variable. The flowers are most often grenadine to peach-red but may be mauve or almost white. They have five petals that are not quite symmetric. The numerous stamens and divided pistil are reddish, forming an attractive center for the blossom. The stamens are all united at their bases into a tube surrounding the pistil. This structure is characteristic of all mallows.*

Herbicide Application Section

Herbicide applications can be effective, but little information is usually known about the selectivity of a particular herbicide on newly invasive species. If the weed is a broadleaf, start with a phenoxy herbicide, such as 2,4-D, and closely monitor effectiveness. These herbicides are effective in controlling most broadleaf weeds and allow grasses to continue growing. However, before selecting a particular herbicide, determine the effect it might have on the desired vegetation. Typically, it is not possible to selectively kill the invader without killing a few desired plants. Moreover, you'll want to reestablish desired vegetation and many herbicides can persist in the soil and prevent successful reestablishment. If patches are small it might be worthwhile to use Tordon™ or other residual herbicides to completely kill the infestation and then closely monitor vegetative reestablishment.

Nonselective herbicides will kill all vegetation and require a reestablishment of desired vegetation. Glyphosate, sold as Roundup™ and other products, will kill all existing vegetation, but will not persist to cause problems with vegetative reestablishment.

Selecting Chemicals
Selection of an appropriate chemical or combination of chemicals should be based on consideration of the following factors:

- Label approval for use
- Ground and surface water pollution concerns
- Use of the crop
- Crop and variety tolerance
- Potential for soil residues that may affect following crops
- Kinds of weeds
- Soil texture
- pH of soil
- Amount of organic matter in the soil
- Formulation of the chemical
- Application equipment available
- Potential for drift problems
- Tillage practices
- Herbicide performance
- Herbicide cost
- Herbicide resistant crop

The information in this publication and on product labels will help you select and use chemicals properly according to the above factors. Proper application of chemicals is essential for obtaining satisfactory results. Follow the suggested rates on labels for specific soil and weed situations carefully. Apply herbicides at the times specified. Delayed applications usually result in poorer weed control and may injure the crop.

Weather conditions will affect herbicide performance. Weed control from soil-applied herbicides may be poor if there is insufficient rain soon after treatment, which will make timely cultivation necessary to control emerging weeds. If rainfall is very heavy, some herbicides may be moved downward in the soil, resulting in poor weed control and/or crop injury. Temperature and moisture conditions affect the weed control and crop injury resulting from herbicides applied postemergence. Observe label precautions regarding weather conditions and crop and weed size when applying herbicides.

Liquid and granular formulations of herbicides can be equally effective if they are used properly. Neither should be applied if rain is expected within 24 hours of application. For best results, the turf should NOT be mowed or watered for at least 24 hours following application of either granular or liquid products.

Granular herbicides will be most effective if applied to grass that is moist (from morning dew, rainfall, or irrigation) because the granules will adhere to the wet surfaces of the weeds.

Care should always be exercised when applying herbicides near trees, shrubs, flowerbeds, and vegetable gardens. Drift from spray applications or misdirected application of granular products can result in damage or death of these plants. It is important that dicamba NOT be applied within the dripline of trees or shrubs. Dicamba can be root absorbed by these plants, possibly resulting in damage.

Postemergence Herbicides

Postemergence herbicides are used to kill weeds after the weed plants are up and growing. To be effective, most postemergence herbicides must be absorbed through the leaves; consequently, liquid sprays generally work better than dry, granular materials.

However, granular formulations may be the most practical way for homeowners to apply these materials.

Postemergence herbicides are most effectively applied when weeds are young and growing vigorously.

Selective postemergence herbicides are usually used to control annual, biennial, and perennial broad-leaved weeds because they will kill many broadleaf plants without damaging grass plants. These herbicides can severely damage or kill trees, shrubs, and flowers; thus, they should be used with great care near these plants.

Postemergence herbicides may be applied any time the weeds are actively growing, the air temperature is 60–80°F, there are no winds, and there is no rain in the forecast for 48 hours. Most effective control of perennial broadleaf weeds is obtained when applied in early fall (August 15–October 15) or in spring (May 1–June 1). For some weeds, repeated application at 20–30 day intervals may be required for control.

Nonselective postemergence herbicides kill all plants, both desirable and undesirable. These herbicides can be used to spot treat perennial grassy weeds that are not affected by selective herbicides. To spot treat an area, thoroughly wet the weed foliage with herbicide solution.

Pre-emergence or selective pre-emergence granular materials may be applied with a fertilizer spreader. The spreader must set or be calibrated to apply recommended rates. The preferred method of application is to apply one-half the recommended rate in one direction and one-half at a right angle to that direction.

Compressed air sprayers or sprayers attached to a garden hose are effective for liquid applications. Remember that the higher the pressure and the finer the mist, the more likely it is that the herbicide will drift and injure shrubs, trees, flowers, and vegetables.

Sprinkler cans can be used on small areas, but once any applicator has been used to apply herbicides, it should not be used to spray other pesticides on ornamental or garden plants. You should use a separate sprayer for killing weeds. Be sure to clean the sprayer thoroughly after each use.

Weed Control Table #1

Weed Control	Life Cycle(1)	Recommended Chemical(2)	Time of Application	Degree of Control
Bindweed	P	2,4-D ester or dicamba(4)	early summer	good
Black medic	A	dicamba(4)	early spring	good
Chickweed, common	A	MCPP or dicamba(4)	spring or fall	good
Chickweed, mouse-ear	P	MCPP or dicamba(4)	fall or spring	good
Chickory	P	2,4-D	spring	good
Cinquefoil	P	2,4-D	fall or spring	good
Dandelion	P	2,4-D or dicamba(4)	fall or spring	good
Dock, curly	B	2,4-D or dicamba(4)	fall or spring	good
Garlic or onion	P	2,4-D ester	late fall, early spring	fair
Ground ivy	P	dicamba(4,6)	summer, fall or spring	fair-good
Heal-all	P	2,4-D	spring	good
Henbit	A	dicamba(4)	spring	good
Knotweed	A	dicamba(4,6)	spring to mid-summer	good
Mallow roundleaf	A	dicamba(4)	spring	fair
Pigweed	A	2,4-D or MCPP	summer	good
Plantain, buckhorn	P	2,4-D or MCPP	fall or spring	fair
Plantain, common	P	2,4-D or MCPP	fall or spring	good
Poison ivy	P	Amitrol-T or Roundup(5)	spring or summer	good
Purslane	A	dicamba(4)	spring or fall	good
Red sorrel	P	dicamba(4)	spring, summer or fall	good
Speedwell, creeping	P	2,4-D, MCPP or Dicamba	fall or spring	good
Speedwell, annual	A	dacthal	spring or fall	fair
Spurge, spotted	A	dicamba(4,6) or MCPP	summer	fair-good
Sow thistle	A	2,4-D or dicamba(4)	fall	good
Thistle(3)	P	dicamba(4)	spring	fair-good
Wild violet	P	dicamba(4,6) or triclopyr	spring or fall	fair-good
White clover	P	MCPP or dicamba(4)	spring, summer or fall	good
Wild carrot	B	2,4-D or dicamba(4)	fall or spring	good
Wood sorrel (Oxalis)	A	2,4-D ester, MCPP or dicamba(4,6)	early summer	fair-good
Yarrow	P	dicamba(4)	spring	fair
(1) A = Annual, B = Biennial, P = Perennial.				

(2) Do not use 2,4-D on golf course greens and use with caution on other bentgrass turf.
(3) Three or more applications may be necessary to eradicate thistle.
(4) Dicamba may accumulate in the soil with frequent or extensive use which may result in damage to trees, shrubs, or other ornamentals.
(5) Nonselective herbicides. Spot treat only.
(6) 2,4-D plus dichlorprop (Weedone formulations) 2,4-D plus triclopyr (Turflon formulations) and triclopyr plus clopyralid (Confront) are effective combinations for many broadleaf weeds, including hard-to-control species such as ground ivy, wood sorrel (oxalis), spotted spurge and wild violets.

Grass Weeds Table #2

Annual bluegrass (A, P) Barnyardgrass (A) Crabgrass (A) Foxtail (A) Goosegrass (A)	Use pre-emergence herbicides. Apply two to three weeks prior to expected germination of weed seeds. Some of these herbicides may injure fine fescues or bentgrasses. Most pre-emergent herbicides will harm newly seeded grasses except siduron (Tupersan).
Bromegrass (P) Quackgrass (P) Tall Fescue (P) Creeping bentgrass (P)	These weeds can be controlled only with nonselective herbicides. Spot treat only because herbicide will also kill desirable grass plants. Apply when weeds are actively growing.

A = Annual

P = Perennial

WA = Winter annual

Herbicidal Summary
Requires precision calculations, equipment, and application.

Selectivity
- Crop naturally tolerates herbicide (internal selectivity).
- Placement of herbicide prevents crop exposure.
- Timing of application to avoid susceptible stage of growth.
- Labeling requires extensive testing.
- Toxicology includes acute, subacute, and chronic toxicity; teratology (fetus); reproduction, mutagenicity (cancer); neurotoxicity (nerves); and metabolism studies along with worker exposure.
- Environmental fate includes breakdown, groundwater, ecological effects on plants and animals.
- Tolerance assessment considers normal application procedures and preharvest intervals for assessing residues within food products.

Crop Herbicide Table # 3

S. No.	Family or natural order	Descriptive features of the family	Habit and habitat of weeds	Herbicide recommendations
	(1)	(2)	(3)	(4)
1.	Acanthaceae (acanthus family)	Herbs or shrubs. Leaves, opposite, ex-stipulate. Flowers, bisexual, irregular. Calyx 4-5 partite. Corolla, two-lipped and five-lobed. Stamens, four or two, epipetalous. Fruit, a capsule.	*Justicia quinqangularis,* an annual *Kharif* season weed, occurring in crops, like rice, maize, sugarcane and cotton.	In the case of rice, MCPA or MCPB @ 5kg ha+urea 3% in 700 liters of water 3-4 weeks after direct seeding or transplanting. In the case of cotton, CMU pre-emergence @ 0.5- 1.0 kg/ha in 900 liters 0f water. In the case of maize and sugarcane, Atrazine or Simazine pre-emergence @ 1 kg/ha in 900 liters of water.
2.	Amaranthaceae (pigweed family)	Leaves, alternate; flowers, small, without petals, subtended by small bristly bracts. Fruit, one seeded, the thin pericarp releases the lens-shaped, shiny black seeds	*Amaranthus spinosus(kataili chulai)* Annual a. *viridis* Annual Reported to grow in sugarcane, maize, rice and onion A. *polygamous (Csiru kearai) Celosia argentea,* cock's comb (*sufaid murga*); Annual. *Digera arvensis(tendala)* Annual, a *kharif* season weed occurring in millets, maize, sugarcane and cotton; *Achyranthes aspera;(chirchiri)* in wasteland	In the case of rice, MCPA or MCPB @0.5 kg/ha + urea 2%. In the case of cotton, CMU pre-emergence @ 0.5-1.0 kg/ha 2-3 weeks after transplanting.(Other details given above)
3.	Asclepiadaceae (milk-weed family)	Herbs or shrubs with milky juice. Leaves,opposite ex-stipulate. Flowers,regular,bisexual and in umbellatem clusters. Calyx,5-lobed; corolla, gamopetalous. Stamens, five and filaments and united. Fruit consists of two follicles.	*Calotropis gigantea.* A large shrub. Mostly seen on waste and submarginal land.	Suspectable to 2,4-D amine 1-2 l/ha in 900 liters of water before flowering.

4.	Boraginaceae	Leaves, alternate, exstipulate; flower, regular; corolla, gamopetalous; stamens, 5, attached to the corolla tube. Fruit, a drupe, or breaks into 2-4 nutlets.	*Heliotropium eichwaldi* Annual H. *indicum* Annual Reported to occur in sugarcane, maize and cotton.	In the case of sugarcane and maize, Atrazine or Simazine @ 1 kg/ha. For other details refer to No.1.
5.	Cannabinaceae or Urti caceae (nettle family)	Plants annual. Leaves, palmately compound in *Cannabis* Flowers, greenish; male flowers, borne in long drooping panicles and female flowers borne in short axillary spikes.	*Cannabis sativa* Annual, *(bhang)* dioecious in nature. Occurs on wasteland, bunds and water channels.	Susceptible to 2,4-D ester or a mixture of 2,4-D+2,4,5-T @ 1.0-2.0/ha during flowering or earlier.
6.	Chenopo diaceae (goosefoot family)	Leaves, alternate; flowers small, without petals, no bristly bracts. Fruit, one-seeded and the pericarp is adherent to the seed.	*Chenopodium album* (lamb's-quarters) (bathua) C. *murale (khar bathua)* Annual *rabi*-season weeds, dominant in *rabi* cereals, peas, potato, linseed and carrot.	In the case of monocot crops, 2,4-D amine @0.5 kg/ha+urea 3 percent in 700 liters of water, 3-4 weeks after sowing. In the case of peas and linseed, MCPB @ 0.84 l/ha in 700 liters of water 6 weeks after sowing. In the case of potato and carrot, Linuron @ 0.5 kg/ha pre-emergence. In the case of sugar-beet, a pre-emergence soil application of Pyrazon at 2-3 kg/ha in 1,000 liters of water is very effective against *Chenopodium* spp. and other annual dicot weed.
7.	Compositae (sunflower family)	Flowers aggregated in heads comprising outerray flowers and inner tubular or disc flowers.	*Carthamus oxyacantha* Annual (wild safflower or *pohli) Sonchus oleraceus* Annual (The common sowthistle or *doodhli) Ageratum conyzoides (mahakama)* Annual *Cnicus arvensis (kantaili)* Annuala *rabi* crops such as wheat, potato, linseed and peas.	In the case of monocot crops(Refer item No. 6). In the case of potato and peas Linuron @ 0.5 kg/ha pre-emergence in 900 liters of water. In the case of linseed MCPB (Refer item No. 6). In the case of non-cropped areas, a spraying with any one of 2, 4-D, aminotriazole, Paraquate Banvel D and MSMA at 2-4 liters/ha before flowering will kill the weed and prevent its flowering and seed production. For Canada thistle; 2,4-D low volatile ester 1.5 l/ha in 900 liters of

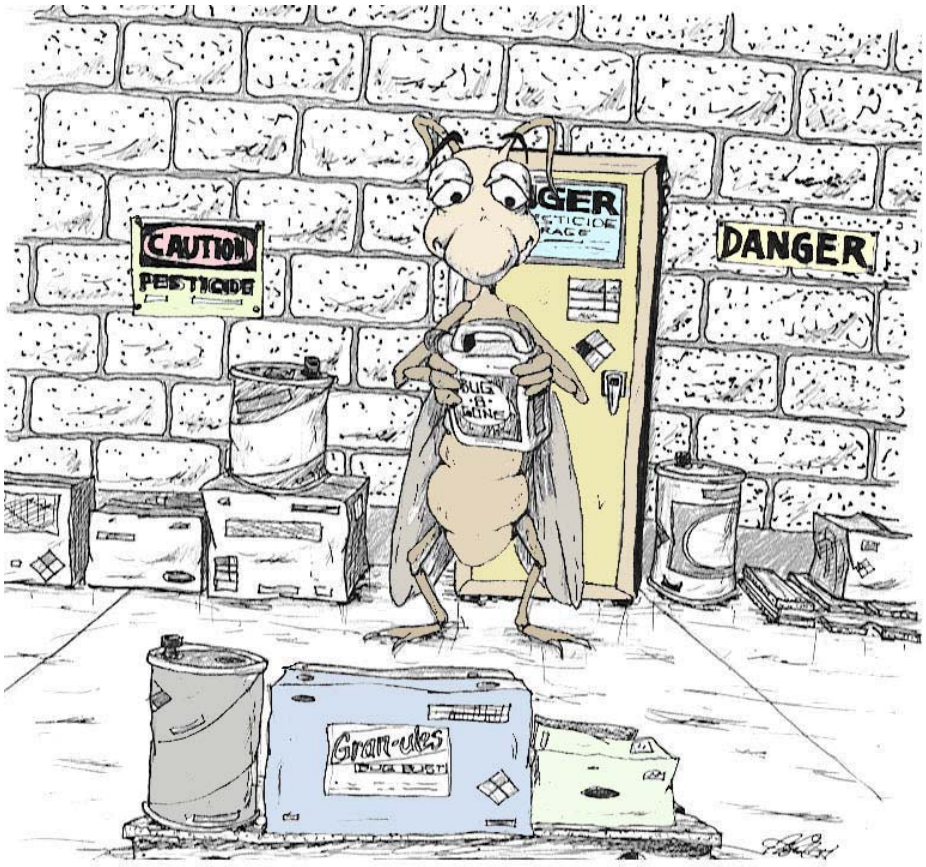
			Parthenium hysterophorus Annual *(congress ghas, safed topi, chamakta chandni)*. Prolific-seeder, extensively spread because of light seed, armed with pappus that facilitates its dispersal through natural agencies, such as wind, water, air and animals including man. *Cirsiumarvense,* Perennial (Canada thistle) *Plushea lanceolata,* Perennial *(baisuri or kadjal)*. Reproduction through underground rhizomes. Mostly found in non-cropped areas.	water at the early bloom stage or aminotriazole at 2 kg l/ha+ a wetting agent (6fl. oz) spray at the flowering stage.
8.	Convolvulaceae (morning-glory family)	Plants, viny, trailing or twining, Leaves, alternate, entire, with a pair of basal lobes. Flowers, large, gamopetalous, with a basal tube and a spreading limb. Fruit, a 2-chambered capsule, with 2-5 seeds in each chamber.	*Convolvulus arvensis,* Perennial (field bindweed or *hirankuri) Ipomoea reptans* Aquatic weed, *Evolvulus alsinoides (Vishnu krantha)* Dodders ao *Cuscuta* spp. Flowering parasites.	For field bindweed and *ipomoea reptans*: In non-cropped land and monocot crops, 2,4-D amine 1.0 liter/ha + urea 3 percent in 900 liters of water before flowering of the weed. For dodder 2kg/ha granulated CIPC.
9.	Cruciferae (mustard family)	Leaves, alternate. Flowers cruciform (cross-like), with 4 sepals, 4 petals and 6 stamens. Fruit, a siliqua, podlike, or short and flattened, with two chambers separated by a	*Brassica sinensis* (wild mustard or *jungli sarson), Sisymbrium irio, Nasturtium indicum.*	In the case of peas and potato. Linuron (Ref. No. 7).In wheat, 2,4-D + urea (Ref. No. 6). In the case of linseed, MCPB (Ref. No. 6)

		central partition bearing two to several seeds, usually dehiscent.		
10.	Cyperaceae (sedge family)	Stems, solid and 3-angled. Leaves, similar to those of grasses, with a linear blade and basal sheath; leaf sheath forming a closed tube around the stem. Flowers, without petals, variously arranged often in spikes, enclosed by a single bract. Fruit, a flattened or 3-angled achene, with a thick hard pericarp.	*Cyperus rotundus* (Nutgrass or purple nutsedge or *motha C. esculentus* (Yellow nutsedge present in the USA) *C. iria* Perennial. Present in both cropped and non-cropped land all over the world. Reproduction through vegetative means.	An effective method of controlling nutsedge in arable land consists in giving 2-4 ploughings during May and June; immediately after each ploughing spray on the soil a mixture of 2,4-D + Dalapon 2 kg/ha of each in 900 liters of water, sowing of hybrid maize in the last week of June, using atrazine pre-emergence @ 1 kg/ha in the case of maize, and after maize, raise a wheat crop in the *rabi* season.
11.	Euphor biaceae (Spurge family)	Plants, diverse as to vegetative characters. Common species, with milky juice. Flowers, much reduced, without petals, in some species with colored bracts which resemble petals. Fruit, usually a 3-lobed, 3-chambered capsule, with one seed in each chamber.	*Euphorbia prostrata* Annual (milkweed E.*hirta(dudhi),,* E.*racunculoaies,,* Reported to occur in wheat, gram, millet and maize *Phyllanthus niru.i* Reported to occur in rice.	Except in the case of gram, 2,4-D,or MCPA or MCPB at 1 Kg/ha in 700 liters of water will kill these weeds.
12.	Grami neae (grass family)	Plants with hollow round or flat stems (culms). Leaves, arranged in two rows on the opposite sides of the stem, consisting of a blade, a sheath and a ligule. The blade is entire, linear, and parallel-veined. The flower consists of a pistil and three stamens. Each flower is enclosed by a pair	*Echinochloa crusgalli* <(barnyard grass)*(samaghas) E. colonum* An annual *kharif* season weed dominant in rice. *Cynodon dactylon* (Bermuda grass or *doob*. Perennial in almost all crops and situations. *Saccharum spontaneum*(wild sugarcane or	In case of rice, propanil 2 liters/ha in 700 liters of water 2-3 weeks after transplanting or direct seeding. For annual grasses in cotton, treat with pre-plant Treflan 2 i/ha or Diuron or Cotoran 0.5-1.0 kg/ha pre-emergence. In the case of maize and sugarcane, Atrazine pre-emergence (Ref. no. 4). For *Cynodon,* a combination of mechanical and chemical, and cropping methods (Ref.No.10). For wild oats in wheat and barley, Carbyne

		of unequal bracts, one on each side, the larger is the lemma and the smaller is the palea. The unit consisting of the flower, lemma and the palea is the floret. The florets are arranged in spikelets each of which consists of central axis, a pair of bracts (glumes) at the base, and one to several florets above. Fruit, a grain or caryopsis, 1-seeded, the fruit coat permanently adherent about the seed.	*kans*) Perennial, reported to occur in sugarcane, cotton and millets. *Sorghum halepense*(Johnson grass or *baru*) Perennial, reported to occur in sugarcane, maize and cotton. *Avena fatua* (wild oats or *Jungli jai) A. ludoviciana* Annual, reported to occur in wheat, peas, potato, gram and linseed. *Phalaris* spp. Annual Reported to occur in *rabi* crops.	(Barban) @0.5 i/ha at the 2 leaf-stage of the weed as a very low-volume spraying or preplant Avadex(trillate) at 2 l/ha. *Phalaris sp.* in wheat is controlled effectively by a pre-emergence application of Tribunil at 2 kg/ha in 900 liters of water. A single application of this chemical, in addition to killing this annual grass weed, is also lethal to all annual dicot weed.
13.	Labiatae (mint family)	Plants, with square stems and aromatic odor. Leaves, simple, exstipulate, opposite toothed or lobed. Flowers, gamopetalous, irregular, 2-lipped. The fruit, consists of usually 4, dry single-seeded nutlets.	*Leucas aspera* Annual *Ocimum canum* Annual	Suceptible to 2, 4-D amine 1 kg/ha in 900 liters of water.
14.	Legumin osae(legume family)	Leaves, alternate, compound, with three leaflets. Flowers irregular with a larger petal(standard), 2-side petals (wings), and two inner petals which are fused(keel) and enclosed the pistil and stamens. Fruits, a pod, 1-celled. Several-seeded and dehiscent, e.g. bean pod or one-seeded and	*Melilotus* (white sweet clover). Annual, in *rabi* crops. *M. indica(senji)* Annual in *rabi* crops. *Vicia sativa* (common vetch) Annual in rabi crops. *Tephrosia purpurea.* A perennial under-shrub in arid tracts. *Prosopis juliflora*(mesquite) A perennial small tree in non-cropped land. *Alhagi camelorum*	2, 4-D in cereals at 1 kg/ha kills the annual legumes. For perennials, a mixture of 2, 4-D and 2, 4, 5-T at 1-2 l/ha before flowering.

		indehiscent(sweet clover)	(Camelthorn or javasa). A thorny perennial in fallow land. *Mimosa pudica* (touch-me-not or *lajjavanti)*. A thorny perennial.	
15.	Orbanch aceae (broomrape family)	Brown or yellowish herbs, without green leaves and parasitic on the roots of other plants. Stem, simple with a few scales and ends in a spike of flowers, irregular and bisexual, calyx, 2-4-lobed; corolla, gamopetalous, stamens 4, didynamous and epipetalous, numerous seeds.	*Orobanche cernua* (broomrape) *O. indica* An annual root parasite on tobacco, mustard, etc.	Eradication with chemicals without affecting the host plants is difficult the removal of immature plants as they emerge from the soil and before they form seeds prevents its spread. Heavy infested areas can be reclaimed by growing a trap crop and spraying with 1-2 i/ha of amine 2, 4-D. 2, 4-DES at 6 kg/ha in 1,000 liters of water applied at 4-6 week intervals or in split applications at 3 kg/ha each time 2 and 6 weeks after transplanting tobacco; reduce the population of broomrape plants considerably. Sprays with amyl alcohol (0.1-0.2 per cent) are reported to be effective against broomrape in tobacco.
16.	Papaver aceae (poppy family)	Annuals, with prickly stems and leaves. Juice, yellow-orange. Sepals, 2 or 3, falling off when the flower opens. Petals, 4,stamens, many. Fruit, a capsule, many seeds, with oily endosperm	*Argemone nexicana* (prickly poppy or *bharbhand* or *satyanasi*). Annual, spread all over India, in all crops, especially wheat and mustard	In the case of monocot crops, 2, 4-D amine+urea (Ref. No. 6). In mustard, nitrofen pre-emergence 1-2 l/ha in 900 liters of water.
17.	Ponteder iaceae (water hyacinth family)	The family consists of erect or floating fresh water and marsh herbs. Flowers, bisexual more or less irregular usually in a recemose inflorescence from a spathe like bract. Perianth, tubular consisting of six	*Eichhornia crassipes* (water hyacinth). A free-floating or surface perennial, one of the worst aquatic weed, occurring all over the globe.	2, 4-Dester of low volatility @ 1-2 kg in 700 liters of water during the active growing season; Amitrole-T 2 i/ha in 00 liters of water at peak growth; repeat the application of Paraquat 2 i/ha. The addition of urea 3 percent to low doses of any of the post-emergence herbicides at lower dosage

		petal like parts in two whorls. Stamens, 6, unequal, attached, to the perianth tube.		levels(1 kg or l/ha) improves the weed killing effect.
18.	Scrophulariaceae (figwort family)	Herbs, sometimes semiparasitic, or shrubs. Leaves, exstipulate. Flowers, bisexual and usually irregular. Calyx, 4-5 lobed and 2-lipped. Stamens, usually 4, epipetalous and didynamous. Fruit, a capsule, with many seeds.	*Striga asiatica* (witch weed) *S.lutea S.euphrasioides* Annual root; parasites reported to occur in bajra, sorghum, sugarcane and rice.	In the case of monocot crops, 2,4-Damine @ l/ha in 900 liters of water soon after the germination of the parasite; fence @ 3 kg/ha in 700 liters of water as pre-planting soil incorporation, especially in the case of sugarcane.
19.	Solanaceae (potato family)	Leaves, alternate. Calyx, five-lobed; flowers, gamopetalous, regular, tubular or with tube and expanded limb. Stamens, 5, attached to the corolla tube. Fruit, a berry or a capsule with many seeds.	*Solanum Xanthocarpum(kateli)* A perennial spiny herb. *Solanum elaeagnifolium* (white horse nettle) Perennial, reported to be very prevalent in southern India.	2,4,5-T @ 1 kg/ha in 1,000 liters of water at the young stage before leaves become tough. For *Solanum elasagnifolium,* 2,4-D amine foliar spray during the period of active growth at 2 liters/ha in 900 liters of water effects remarkable reduction in the regeneration of the weed control. After this chemical treatment, if the land is cropped to sorghum, the further spread of this perennial weed control is prevented.
20.	Typhaceae	Typhas are gregarious, robust, grass-like herbs, attaining a height of even 3m and flourishing under water-logged conditions. Flowers are small in long dense cylindrical, terminal spikes.	Cattails and tules *(Typha sp.)* Aquatic emersed perennials	Dalapon @ 5kg+ wetting agent 0.5 kg to be sprayed during the active growth of Aminotriazole 1 kg+a wetting agent or 2,4-D as an ester of low volatility @ 1 kg+diesel oil in 4.5 liters in 500 liters of water.
21.	Verbenaceae (vervain family).	Herbs, shrubs or trees, exstipulate leaves; calyx 4-5 or more-lobed and sometimes colored. Corolla, tube has a 2-lipped or 4-5-lobed limb.	*Lantana camara perennial(tantani)* shrub.	A mixture of 2, 4-D+ 2, 4, 5T (Brush killer) at 1-2 kg in 1,000 liters of water at the pre-bloom stage



§ 156.208 Restricted-entry statements.

(a) Requirement. Each product with a restricted-entry interval shall bear the following statement: "Do not enter or allow worker entry into treated areas during the restricted-entry interval (REI)." This statement shall be under the heading AGRICULTURAL USE REQUIREMENTS in the labeling.

(b) Location of specific restricted-entry interval statements. (1) If a product has one specific restricted-entry interval applicable to all registered uses of the product on agricultural plants, the restricted-entry interval for the product shall appear as a continuation of the statement required in paragraph (a) of this section and shall appear as follows: "of X hours" or "of X days" or "until the acceptable exposure level of X ppm or mg/m3 is reached."

(2) If different restricted-entry intervals have been established for some crops or some uses of a product, the restricted-entry statement in paragraph (b)(1) of this section shall be associated on the labeling of the product with the directions for use for each crop each use to which it applies, immediately preceded or immediately followed by the words "Restricted-entry interval" (or the letters "REI").

(c) Restricted-entry interval based on toxicity of active ingredient--(1) Determination of toxicity category. A restricted-entry interval shall be established based on the acute toxicity of the active ingredients in the product. For the purpose of setting the restricted-entry interval, the toxicity category of each active ingredient in the product shall be determined by comparing the obtainable data on the acute dermal toxicity, eye irritation effects, and skin irritation effects of the ingredient to the criteria of § 156.10(h)(1). The most toxic of the applicable toxicity categories that are obtainable for each active ingredient shall be used to determine the restricted-entry interval for that product. If no acute dermal toxicity data are obtainable, data on acute oral toxicity also shall be considered in this comparison. If no applicable acute toxicity data are obtainable on the active ingredient, the toxicity category corresponding to the signal word of any registered manufacturing-use product that is the source of the active ingredient in the end-use product shall be used. If no acute toxicity data are obtainable on the active ingredients and no toxicity category of a registered manufacturing-use product is obtainable, the toxicity category of the end-use product (corresponding to the signal word on its labeling) shall be used.

Herbicide Mixtures

There are many possibilities for reducing weed control costs while still attaining good weed control. Wise selection of weed control practices and herbicides to fit specific field situations is the key. Identify your weeds and develop an effective, low cost control program that is suitable for the crop you plan to grow. Using band applications of herbicides in row crops, supplemented with cultivation, may save you money.

Reducing herbicide rates below those recommended increases the possibility of costly weed control failure. On the other hand, applying herbicides at greater than recommended rates adds unnecessarily to your weed control costs and may result in crop injury or herbicide carryover. Applying herbicides at the proper time and rate with a carefully calibrated applicator provides the best return on your herbicide investment.

Herbicide Mixtures
Herbicide mixtures are used to overcome limitations of single chemicals. Certain mixtures may:
(1) control more kinds of weeds,
(2) give more consistent performance with variable soils and weather conditions,
(3) lessen soil residue problems,
(4) increase persistence enough to give full-season weed control, or
(5) reduce crop injury.

Only those mixtures that have been field tested under local conditions should be used. Use of some mixtures may result in poor weed control or crop injury. Growers or applicators may be responsible for chemical residues in crops, crop injury or lack of weed control resulting from use of unlabeled mixtures.

Safety Precautions
Always follow the precautions and use restrictions on the label carefully to help protect the operator, avoid crop injury, and prevent harmful residues in food and feed crops. Use herbicides only on crops specified on the label. Use only the recommended amount of herbicide; applying too much of a herbicide may damage the crop, may be unwise if the crop is to be used for food or feed, and is costly. Apply herbicides only at times specified on the label; observe the recommended intervals between treatments and pasturing or harvesting of crops. Wear goggles, rubber gloves, and other protective clothing as recommended on the label. Prevent drift onto nearby susceptible plants. Return larger quantities of unused herbicides in unopened containers to the manufacturer or store them properly until used. Dispose of empty containers in a safe manner:

- Triple rinse container thoroughly with water and use the rinse water in the sprayer.
- Bury small and decomposable containers in approved and supervised sanitary landfills.
- Send empty metal pesticide containers of 15 gallon capacity or more back to the manufacturer or to professional drum reconditioners.
- Observe special label instructions relating to disposal.

Groundwater and Surface Water Contamination
The potential for ground and surface water pollution with pesticides is a growing concern. Good land stewardship dictates that herbicide characteristics must be assessed in relation to their ground or surface water pollution potential, in addition to choosing the most effective and economical weed control. Growing public concern and increasing frequency of detections of minute levels of pesticides in groundwater will result in regulatory action if corrective measures are not taken. Atrazine is the most commonly detected herbicide in well monitoring studies. Sink-holes and shallow soil over porous, fractured limestone bedrock poses a real problem for managing certain herbicides such as atrazine in the karst area. The same situation also exists where permeable sands over shallow water tables occur.

Alternatives to atrazine should be considered in these areas to reduce pollution concerns.

Also, other herbicides have ground or surface water advisory statements on their labels. Use these compounds in sensitive areas only after assessing site specific pollution potential.

The levels of pesticides being detected in groundwater are generally in the parts per billion (ppb) range and are below current health advisory levels considered safe for drinking water. These levels often represent less than 1/1000th of the amount applied to the field, alluding to the difficulty in managing pesticide pollution. Point source concerns are often suspect if levels in a well over a few ppb are detected. Point source problems are those directly attributable to a confined area, event, or site such as mixing or manufacturing sites. Point source contamination may be responsible for a large portion of pesticide detections in wells in some areas of the state. They are relatively easy to correct. Point source problems can be reduced by the following:

- Mix chemicals in the field using a 'water only' nurse tank thereby keeping pesticides away from wells and water sources.
- If chemicals must be mixed at the well site, use hoses to maintain at least a 150 ft. buffer from the well to the spray tank, 100 ft. buffer with safeguards, or 50 ft. with safeguards and a roof present.
- Keep filling hoses out of the spray tank, use check valves, and Do Not leave tanks unattended while filling to avoid backsiphoning or overflow.
- Never dump rinsate or concentrated product in a localized area. Dispose of rinsate by applying to a labeled crop site.
- Triple rinse herbicide containers before disposal or return.
- Properly construct, grout, and case new well construction. Properly cap and seal abandoned wells.

This course contains EPA's federal rule requirements. Please be aware that each state implements pesticide regulations that may be more stringent than EPA's regulations and these frequently are changed. Check with your state environmental/pesticide agency for more information.

Common Herbicide Information Section
Diquat dibromide

Trade and Other Names: Trade names include Aquacide, Aquakill, Dextrone, Diquat, Reglone, Reglox, Reward, Tag, Torpedo, Vegetrole, and Weedtrine-D.

Regulatory Status: Diquat dibromide is a moderately toxic compound in EPA toxicity class II. It is a General Use Pesticide (GUP). Labels for products containing diquat dibromide must bear the Signal Word **WARNING**.

Chemical Class: desiccant

Introduction: Diquat dibromide is a nonselective, quick-acting herbicide and plant growth regulator, causing injury only to the parts of the plant to which it is applied. Diquat dibromide is referred to as a desiccant because it causes a leaf or an entire plant to dry out quickly. It is used to desiccate potato vines and seed crops, to control flowering of sugarcane, and for industrial and aquatic weed control. It is not residual; that is, it does not leave any trace of herbicide on or in plants, soil, or water.

Formulation: Not Available

Toxicological Effects:

- **Acute toxicity:** Diquat dibromide is moderately toxic via ingestion, with reported oral LD50 values of 120 mg/kg in rats, 233 mg/kg in mice, 188 mg/kg in rabbits, and 187 mg/kg in guinea pigs and dogs. Cows appear to be particularly sensitive to this herbicide, with an oral LD50 of 30 to 56 mg/kg. The acute dermal LD50 for diquat dibromide is approximately 400 to 500 mg/kg in rabbits, indicating moderate toxicity by this route as well. A single dose of diquat dibromide was not irritating to the skin of rabbits, but repeated dermal dosing did cause mild redness, thickening, and scabbing. Moderate to severe eye membrane irritation occurred when diquat dibromide was administered to rabbits [88]. Ingestion of sufficient doses may cause severe irritation of the mouth, throat, esophagus, and stomach, followed by nausea, vomiting, diarrhea, severe dehydration, and alterations in body fluid balances, gastrointestinal discomfort, chest pain, diarrhea, kidney failure, and toxic liver damage. Skin absorption of high doses may cause symptoms similar to those that occur following ingestion. Very large doses of the herbicide can result in convulsions and tremors . Test animals (rats, mice, guinea pigs, rabbits, dogs, cows, and hens) given lethal doses of diquat dibromide showed a delayed pattern of illness, with onset approximately 24 hours following dosing, subsequent lethargy, pupil dilation, respiratory distress, weight loss, weakness and finally death over the course of 2 to 14 days after dosing. There have been reports of workers who have had softening and color changes in one or more fingernails after contact with concentrated diquat dibromide solutions. In some instances, the nail was shed, and did not grow in again. Several cases of severe eye injury in humans have occurred after accidental splashings. In each case, initial irritation was mild, but after several days, serious burns and sometimes scarring of the cornea developed. Direct or excessive inhalation of diquat dibromide spray mist or dust may result in oral or nasal irritation, nosebleeds, headache, sore throat, coughing, and symptoms similar to those from ingestion of diquat.
- **Chronic toxicity:** Chronic effects of diquat dibromide are similar to those of paraquat. Cataracts, a clouding of the eyes which interferes with light entering the eye, occurred in rats and dogs given 2.5 mg/kg/day and 5 mg/kg/day of diquat dibromide, respectively. Cataracts increased in proportion to the dose given in test animals (cats and dogs). Chronic exposure is necessary to produce these effects. Other effects on the eye (hemorrhage, retinal detachment) may occur at higher dosages. Rats fed dietary doses of 2.5 mg/kg/day over 2 years did not exhibit signs of toxicity other than reduced food intake and decreased growth. In another study using rats, oral doses of 4 mg/kg/day over 2 years produced no

behavioral or other changes in general condition. At this dose level no evidence of change in the kidneys, liver, or myocardium (heart muscle) were seen. This dosage (but not 2 mg/kg/day) caused changes in lung tissues. Repeated or prolonged dermal contact may cause inflammation of the skin, and, at high doses, systemic effects in other parts of the body. These may include damage to the kidneys. Chronic exposure may damage skin, which may increase the permeability of the skin to foreign compounds.

- **Reproductive effects:** Diquat dibromide generally did not reduce fertility when tested in experimental animals. Rats receiving 1.25 mg/kg/day decreased their food intake and showed slowed growth, but had unchanged reproduction. Fertility was reduced in male mice given diquat dibromide during different stages of sperm formation. Neither fertility nor reproduction was affected in a three-generation study in rats given dietary doses of 12.5 or 25 mg/kg/day of diquat dibromide, although some growth retardation was seen at the 25 mg/kg/day dose. Based on this evidence it is unlikely that diquat dibromide will cause reproductive effects in humans under normal circumstances.
- **Teratogenic effects:** Offspring of pregnant rats given a fatal injected dose of 14 mg/kg of diquat dibromide showed evidence of skeletal defects of the collar bone, as well as little or no ear bone formation upon examination. No deformities were found in the unborn offspring of pregnant rats that were injected intraperitoneally with 0.5 mg/kg/day of diquat daily during organogenesis, the stage of fetal development in which organs are formed. Growth retardation was seen in test animals given extremely high doses of diquat. While no actual teratogenesis occurred in rats given single abdominal injections during days 7 to 14 of pregnancy, many rats did not have normal weight gain and bone formation in the unborn was decreased. It is unlikely that diquat dibromide will cause teratogenic effects in humans under normal circumstances.
- **Mutagenic effects:** There is no evidence that diquat dibromide causes permanent changes in genetic material. For example, no mutagenic effects were seen in mice given oral doses of 10 mg/kg/day for 5 days.
- **Carcinogenic effects:** An 80-week feeding study showed that dietary doses of 15 mg/kg/day of diquat did not cause tumors in rats. Likewise, dietary levels of 36 mg/kg/day for 2 years did not induce tumors in rats. Based on the evidence, it appears that diquat dibromide is not carcinogenic.
- **Organ toxicity:** In animals, diquat dibromide may affect the gastrointestinal tract, eyes, kidneys or liver, and the lungs.
- **Fate in humans and animals:** Absorption of diquat dibromide from the gut into the bloodstream is low. Oral doses are mainly metabolized within the intestines, with metabolites being excreted in the feces. Rat studies showed only a small percentage of the applied oral dose (6%) was absorbed into the bloodstream and then excreted in the urine. Dermal, inhalation, or intravenous exposure results in little processing and rapid elimination in the urine. Following subcutaneous injection in rats, excretion of about 90% of the dose occurred in the urine on the first day and almost all of the remainder on the next day. Complete elimination of the herbicide was seen in urine and feces of rats within 4 days of administration of single oral doses of 5 to 10 mg/kg of diquat dibromide.

Ecological Effects:

- **Effects on birds:** Diquat dibromide ranges from slightly to moderately toxic to birds. The reported acute oral LD50 in young male mallards is 564 mg/kg. The oral LD50 for diquat dibromide is 200 to 400 mg/kg in hens. The 5-day dietary LC50 is about 1300 ppm in Japanese quail.
- **Effects on aquatic organisms:** Diquat dibromide is moderately to practically nontoxic to fish and aquatic invertebrates. The 8-hour LC50 for diquat dibromide is 12.3 mg/L in rainbow trout and 28.5 mg/L in Chinook salmon. The 96-hour LC50 is 16 mg/L in northern pike, 20.4 mg/L in fingerling trout, 245 mg/L in bluegill, 60 mg/L in yellow perch, and 170 mg/L in black bullhead. Research indicates that yellow perch suffer significant respiratory stress when herbicide concentrations in the water are similar to those normally present

during aquatic vegetation control programs. There is little or no bioconcentration of diquat dibromide in fish.

- **Effects on other organisms:** Diquat dibromide is not toxic to honey bees. Since diquat dibromide is a nonselective herbicide, it may present a danger to non-target plant species. Cows are particularly sensitive to the toxic effects of this material.

Environmental Fate:

- **Breakdown in soil and groundwater:** Diquat dibromide is highly persistent, with reported field half-lives of greater than 1000 days. It is very well sorbed by soil organic matter and clay. Although it is water soluble, its capacity for strong adsorption to soil particles suggest that it will not easily leach through the soil, be taken up by plants or soil microbes, or broken down by sunlight (photochemical degradation). Field and laboratory tests show that diquat usually remains in the top inch of soil for long periods of time after it is applied.
- **Breakdown in water:** Studies on the erosion of diquat-treated soils near bodies of water indicate that diquat dibromide stays bound to soil particles, remaining biologically inactive in surface waters, such as lakes, rivers, and ponds. When diquat dibromide is applied to open water, it disappears rapidly because it binds to suspended particles in the water. Diquat dibromide's half-life is less than 48 hours in the water column, and may be on the order of 160 days in sediments due to its low bioavailability. Microbial degradation and sunlight play roles in the breakdown of the compound. At 22 days after a weed infested artificial lake was treated, only 1% of the applied diquat dibromide remained in the water and 19% was adsorbed to sediments.
- **Breakdown in vegetation:** Diquat dibromide is rapidly absorbed into the leaves of plants, but usually kills the plant tissues necessary for translocation too quickly to allow movement to other parts of the plant. The herbicide interferes with cell respiration, the process by which plants produce energy. Diquat dibromide is broken down on the plant surface by photochemical degradation. It is rapidly absorbed by aquatic weeds from the surrounding water and concentrated in the plant tissue. Thus, even low concentrations of the herbicide can control aquatic weeds.

Physical Properties:

- **Appearance:** Technical diquat dibromide, which is greater than 95% pure, forms white to yellow crystals.
- **Chemical Name:** 1,1'-ethylene-2,2'-bipyridyldiylium dibromide salt.
- **CAS Number:** 85-00-7
- **Molecular Weight:** 344.06
- **Water Solubility:** 700,000 mg/L @ 20 C; v.s.
- **Solubility in Other Solvents:** i.s. in nonpolar solvents such as chloroform, diethyl ether, and petroleum ether [1]; s.s in alcohol and hydroxylic solvents.
- **Melting Point:** Decomposes above 300 C
- **Vapor Pressure:** Negligible @ 20 C
- **Partition Coefficient:** -4.6021
- **Adsorption Coefficient:** 1,000,000 (estimated)

Exposure Guidelines:

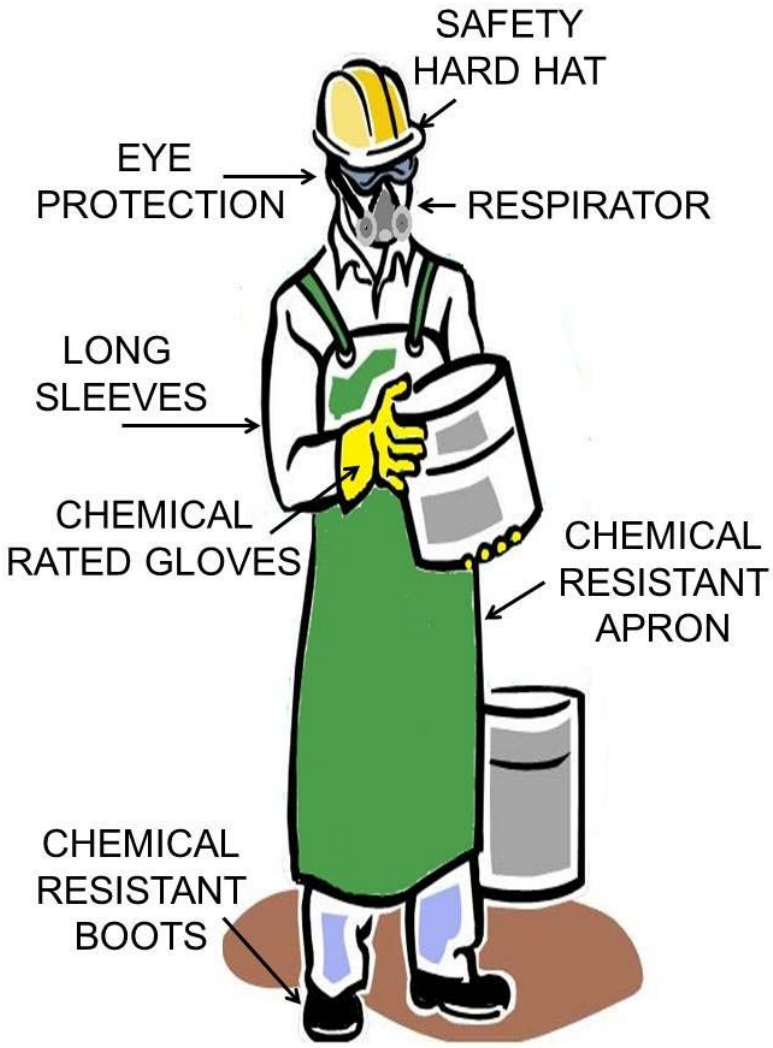
- **ADI:** 0.002 mg/kg/day
- **MCL**: 0.02 mg/L
- **RfD:** 0.0022 mg/kg/day
- **PEL:** Not Available
- **HA**: Not Available
- **TLV**: 0.1 mg/m3 (8-hour) (respirable fraction)

Basic Manufacturer:
Zeneca Ag Products
1800 Concord Pike
Wilmington, DE 19897

- **Phone:** 800-759-4500

- **Emergency:** 800-759-2500

DISCLAIMER: The information in this profile does not in any way replace or supersede the information on the pesticide product labeling or other regulatory requirements. Please refer to the pesticide product labeling.



Glyphosate

Trade and Other Names: Trade names for products containing glyphosate include Gallup, Landmaster, Pondmaster, Ranger, Roundup, Rodeo, and Touchdown. It may be used in formulations with other herbicides.

Regulatory Status: Glyphosate acid and its salts are moderately toxic compounds in EPA toxicity class II. Labels for products containing these compounds must bear the Signal Word **WARNING**. Glyphosate is a General Use Pesticide (GUP).

Chemical Class: Not Available

Introduction: Glyphosate is a broad-spectrum, nonselective systemic herbicide used for control of annual and perennial plants including grasses, sedges, broad-leaved weeds, and woody plants. It can be used on non-cropland as well as on a great variety of crops. Glyphosate itself is an acid, but it is commonly used in salt form, most commonly the isopropylamine salt. It may also be available in acidic or trimethylsulfonium salt forms. It is generally distributed as water-soluble concentrates and powders. The information presented here refers to the technical grade of the acid form of glyphosate, unless otherwise noted.

Formulation: Glyphosate itself is an acid, but it is commonly used in salt form, most commonly the isopropylamine salt. It may also be available in acidic or trimethylsulfonium salt forms. It is generally distributed as water-soluble concentrates and powders.

Toxicological Effects:

- **Acute toxicity:** Glyphosate is practically nontoxic by ingestion, with a reported acute oral LD50 of 5600 mg/kg in the rat. The toxicities of the technical acid (glyphosate) and the formulated product (Roundup) are nearly the same]. The oral LD50 for the trimethylsulfonium salt is reported to be approximately 750 mg/kg in rats, which indicates moderate toxicity. Formulations may show moderate toxicity as well (LD50 values between 1000 mg/kg and 5000 mg/kg). Oral LD50 values for glyphosate are greater than 10,000 mg/kg in mice, rabbits, and goats. It is practically nontoxic by skin exposure, with reported dermal LD50 values of greater than 5000 mg/kg for the acid and isopropylamine salt. The trimethylsulfonium salt has a reported dermal LD50 of greater than 2000 mg/kg. It is reportedly not irritating to the skin of rabbits, and does not induce skin sensitization in guinea pigs. It does cause eye irritation in rabbits. Some formulations may cause much more extreme irritation of the skin or eyes. In a number of human volunteers, patch tests produced no visible skin changes or sensitization. The reported 4-hour rat inhalation LC50 values for the technical acid and salts were 5 to 12 mg/L, indicating moderate toxicity via this route. Some formulations may show high acute inhalation toxicity. While it does contain a phosphatyl functional group, it is not structurally similar to organophosphate pesticides which contain organophosphate esters, and it does not significantly inhibit cholinesterase activity.
- **Chronic toxicity:** Studies of glyphosate lasting up to 2 years, have been conducted with rats, dogs, mice, and rabbits, and with few exceptions no effects were observed. For example, in a chronic feeding study with rats, no toxic effects were observed in rats given doses as high as 400 mg/kg/day. Also, no toxic effects were observed in a chronic feeding study with dogs fed up to 500 mg/kg/day, the highest dose tested.
- **Reproductive effects:** Laboratory studies show that glyphosate produces reproductive changes in test animals very rarely and then only at very high doses (over 150 mg/kg/day) It is unlikely that the compound would produce reproductive effects in humans.
- **Teratogenic effects:** In a teratology study with rabbits, no developmental toxicity was observed in the fetuses at the highest dose tested (350 mg/kg/day). Rats given doses up to 175 mg/kg/day on days 6 to 19 of pregnancy had offspring with no teratogenic effects,

but other toxic effects were observed in both the mothers and the fetuses. No toxic effects to the fetuses occurred at 50 mg/kg/day. Glyphosate does not appear to be teratogenic.

- **Mutagenic effects:** Glyphosate mutagenicity and genotoxicity assays have been negative. These included the Ames test, other bacterial assays, and the Chinese Hamster Ovary (CHO) cell culture, rat bone marrow cell culture, and mouse dominant lethal assays. It appears that glyphosate is not mutagenic.
- **Carcinogenic effects:** Rats given oral doses of up to 400 mg/kg/day did not show any signs of cancer, nor did dogs given oral doses of up to 500 mg/kg/day or mice fed glyphosate at doses of up to 4500 mg/kg/day. It appears that glyphosate is not carcinogenic.
- **Organ toxicity:** Some microscopic liver and kidney changes, but no observable differences in function or toxic effects, have been seen after lifetime administration of glyphosate to test animals.
- **Fate in humans and animals:** Glyphosate is poorly absorbed from the digestive tract and is largely excreted unchanged by mammals. At 10 days after treatment, there were only minute amounts in the tissues of rats fed glyphosate for 3 weeks. Cows, chickens, and pigs fed small amounts of glyphosate had undetectable levels (less than 0.05 ppm) in muscle tissue and fat. Levels in milk and eggs were also undetectable (less than 0.025 ppm). Glyphosate has no significant potential to accumulate in animal tissue.

Ecological Effects:

- **Effects on birds:** Glyphosate is slightly toxic to wild birds. The dietary LC50 in both mallards and bobwhite quail is greater than 4500 ppm.
- **Effects on aquatic organisms:** Technical glyphosate acid is practically nontoxic to fish and may be slightly toxic to aquatic invertebrates. The 96-hour LC50 is 120 mg/L in bluegill sunfish, 168 mg/L in harlequin, and 86 mg/L in rainbow trout. The reported 96-hour LC50 values for other aquatic species include greater than 10 mg/L in Atlantic oysters, 934 mg/L in fiddler crab, and 281 mg/L in shrimp. The 48-hour LC50 for glyphosate in Daphnia (water flea), an important food source for freshwater fish, is 780 mg/L. Some formulations may be more toxic to fish and aquatic species due to differences in toxicity between the salts and the parent acid or to surfactants used in the formulation. There is a very low potential for the compound to build up in the tissues of aquatic invertebrates or other aquatic organisms.
- **Effects on other organisms:** Glyphosate is nontoxic to honeybees. Its oral and dermal LD50 is greater than 0.1 mg/ bee. The reported contact LC50 values for earthworms in soil are greater than 5000 ppm for both the glyphosate trimethylsulfonium salt and Roundup.

Environmental Fate:

- **Breakdown in soil and groundwater:** Glyphosate is moderately persistent in soil, with an estimated average half-life of 47 days. Reported field half-lives range from 1 to 174 days. It is strongly adsorbed to most soils, even those with lower organic and clay content. Thus, even though it is highly soluble in water, field and laboratory studies show it does not leach appreciably, and has low potential for runoff (except as adsorbed to colloidal matter). One estimate indicated that less than 2% of the applied chemical is lost to runoff. Microbes are primarily responsible for the breakdown of the product, and volatilization or photodegradation losses will be negligible.
- **Breakdown in water:** In water, glyphosate is strongly adsorbed to suspended organic and mineral matter and is broken down primarily by microorganisms. Its half-life in pond water ranges from 12 days to 10 weeks.
- **Breakdown in vegetation:** Glyphosate may be translocated throughout the plant, including to the roots. It is extensively metabolized by some plants, while remaining intact in others.

Physical Properties:

- **Appearance:** Glyphosate is a colorless crystal at room temperature.
- **Chemical Name:** N-(phosphonomethyl) glycine

- **CAS Number:** 1071-83-6
- **Molecular Weight:** 169.08
- **Water Solubility:** 12,000 mg/L @ 25 C
- **Solubility in Other Solvents:** i.s. in common organics (e.g., acetone, ethanol, and xylene)
- **Melting Point:** 200 C
- **Vapor Pressure:** negligible]
- **Partition Coefficient:** -3.2218 - -2.7696
- **Adsorption Coefficient:** 24,000 (estimated)

Exposure Guidelines:

- **ADI:** 0.3 mg/kg/day
- **MCL**: Not Available
- **RfD:** 0.1 mg/kg/day
- **PEL:** Not Available
- **HA**: 0.7 mg/L (lifetime)
- **TLV**: Not Available

Basic Manufacturer:
Monsanto Company
800 N. Lindbergh Blvd.
St. Louis, MO 63167

- **Phone:** 314-694-6640
- **Emergency:** 314-694-4000

DISCLAIMER: The information in this profile does not in any way replace or supersede the information on the pesticide product labeling or other regulatory requirements. Please refer to the pesticide product labeling.

This course contains EPA's federal rule requirements. Please be aware that each state implements pesticide regulations that may be more stringent than EPA's regulations and these frequently are changed. Check with your state environmental/pesticide agency for more information.

Agricultural plant means any plant grown or maintained for commercial, research, or other purposes. Included in this definition are food, feed and fiber plants, trees, turf grass, flowers, shrubs, ornamentals, and seedlings (40 CFR).

Farm means any operation, other than a nursery or forest, engaged in the outdoor production of agricultural plants (40 CFR, Section 170.3).

2,4-D

Trade and Other Names: 2,4-D is used in many commercial products. Commercial names for products containing 2,4-D include Aqua-Kleen, Barrage, Lawn-Keep, Malerbane, Planotox, Plantgard, Savage, Salvo, Weedone, and Weedtrine-II.

Regulatory Status: 2,4-D is a General Use Pesticide (GUP) in the U.S. The diethylamine salt is toxicity class III- slightly toxic orally, but toxicity class I- highly toxic by eye exposure. It bears the Signal Word **DANGER - POISON** because 2,4-D has produced serious eye and skin irritation among agricultural workers.

Chemical Class: phenoxy compound

Introduction: There are many forms or derivatives of 2,4-D including esters, amines, and salts. Unless otherwise specified, this document will refer to the acid form of 2,4-D. 2,4-D, a chlorinated phenoxy compound, functions as a systemic herbicide and is used to control many types of broadleaf weeds. It is used in cultivated agriculture, in pasture and rangeland applications, forest management, home, garden, and to control aquatic vegetation. It may be found in emulsion form, in aqueous solutions (salts), and as a dry compound.

The product Agent Orange, used extensively throughout Vietnam, was about 50% 2,4-D. However, the controversies associated with the use of Agent Orange were associated with a contaminant (dioxin) in the 2,4,5-T component of the defoliant.

Formulation: It may be found in emulsion form, in aqueous solutions (salts), and as a dry compound.
Toxicological Effects:

- **Acute toxicity:** The acid form is of slight to moderate toxicity. The oral LD50 of 2,4-D ranges from 375 to 666 mg/kg in the rat, 370 mg/kg in mice, and from less than 320 to 1000 mg/kg in guinea pigs. The dermal LD50 values are 1500 mg/kg in rats and 1400 mg/kg in rabbits, respectively. In humans, prolonged breathing of 2,4-D causes coughing, burning, dizziness, and temporary loss of muscle coordination. Other symptoms of poisoning can be fatigue and weakness with possible nausea. On rare occasions following high levels of exposure, there can be inflammation of the nerve endings with muscular effects.
- **Chronic toxicity:** Rats given high amounts, 50 mg/kg/day, of 2,4-D in the diet for 2 years showed no adverse effects. Dogs fed lower amounts in their food for 2 years died, probably because dogs do not excrete organic acids efficiently. A human given a total of 16.3 g in 32 days therapeutically, lapsed into a stupor and showed signs of incoordination, weak reflexes, and loss of bladder control.
- **Reproductive effects:** High levels of 2,4-D (about 50 mg/kg/day) administered orally to pregnant rats did not cause any adverse effects on birth weights or litter size. Higher doses (188 mg/kg/day) resulted in fetuses with abdominal cavity bleeding and increased mortality. DNA synthesis in the testes was significantly inhibited when mice were fed large amounts (200 mg/kg/day) of 2,4-D. The evidence suggests that if 2,4-D causes reproductive effects in animals, this only occurs at very high doses. Thus reproductive problems associated with 2,4-D are unlikely in humans under normal circumstances.
- **Teratogenic effects:** 2,4-D may cause birth defects at high doses. Rats fed 150 mg/kg/day on days 6 to 15 of pregnancy had offspring with increased skeletal abnormalities, such as delayed bone development and wavy ribs. This suggests that 2,4-D exposure is unlikely to be teratogenic in humans at expected exposure levels.
- **Mutagenic effects:** 2,4-D has been very extensively tested and was found to be non-mutagenic in most systems. 2,4-D did not damage DNA in human lung cells. However, in one study, significant effects occurred in chromosomes in cultured human cells at low

exposure levels. The data suggest that 2,4-D is not mutagenic or has low mutagenic potential.

- **Carcinogenic effects:** 2,4-D fed to rats for 2 years caused an increase in malignant tumors. Female mice given a single injection of 2,4-D developed cancer (reticulum-cell sarcomas). Another study in rodents shows a low incidence of brain tumors at moderate exposure levels (45 mg/kg/day) over a lifetime. However, a number of questions have been raised about the validity of this evidence and thus about the carcinogenic potential of 2,4-D. In humans, a variety of studies give conflicting results. Several studies suggest an association of 2,4-D exposure with cancer. An increased occurrence of non-Hodgkin's lymphoma was found among a Kansas and Nebraska farm population associated with the spraying of 2,4-D. Other studies done in New Zealand, Washington, New York, Australia, and on Vietnam veterans from the U.S. were all negative. There remains considerable controversy about the methods used in the various studies and their results. Thus, the carcinogenic status of 2,4-D is not clear.
- **Organ toxicity:** Most symptoms of 2,4-D exposure disappear within a few days, but there is a report of liver dysfunction from long-term exposure.
- **Fate in humans and animals:** The absorption of 2,4-D is almost complete in mammals after ingestion and nearly all of the dose is excreted in the urine. The compound is readily absorbed through the skin and lungs. Men given 5 mg/kg excreted about 82% of the dose as unchanged 2,4-D. The half-life is between 10 and 20 hours in living organisms. There is no evidence that 2,4-D accumulates to significant level in mammals or in other organisms. Between 6 and 8 hours after doses of 1 mg/kg, peak concentrations of 2,4-D were found in the blood, liver, kidney, lungs, and spleen of rats. There were lower levels in muscle and brain. After 24 hours, there were no detectable tissue residues. Only traces of the compound have been found in the milk of lactating animals for 6 days following exposure. 2,4-D passes through the placenta in pigs and rats. In rats, about 20% was detected in the uterus, placenta, fetus, and amniotic fluid. Chickens given moderate amounts of 2,4-D in drinking water from birth to maturity had very low levels of the compound in eggs.

Ecological Effects:

- **Effects on birds:** 2,4-D is slightly toxic to wildfowl and slightly to moderately toxic to birds. The LD50 is 1000 mg/kg in mallards, 272 mg/kg in pheasants, and 668 mg/kg in quail and pigeons.
- **Effects on aquatic organisms:** Some formulations of 2,4-D are highly toxic to fish while others are less so. For example, the LC50 ranges between 1.0 and 100 mg/L in cutthroat trout, depending on the formulation used. Channel catfish had less than 10% mortality when exposed to 10 mg/L for 48 hours [1,9]. Green sunfish, when exposed to 110 mg/L for 41 hours, showed no effect on swimming response. Limited studies indicate a half-life of less than 2 days in fish and oysters [24]. Concentrations of 10 mg/L for 85 days did not adversely affect the survival of adult Dungeness crabs. For immature crabs, the 96-hour LC50 is greater than 10 mg/L, indicating that 2,4-D is only slightly toxic. Brown shrimp showed a small increase in mortality at exposures of 2 mg/L for 48 hours.
- **Effects on other organisms:** Moderate doses of 2,4-D severely impaired honeybees brood production. At lower levels of exposure, exposed bees lived significantly longer than the controls. The honeybee LD50 is 0.0115 mg/bee.

Environmental Fate:

- **Breakdown in soil and groundwater:** 2,4-D has low soil persistence. The half-life in soil is less than 7 days [21]. Soil microbes are primarily responsible for its disappearance. Despite its short half-life in soil and in aquatic environments, the compound has been detected in groundwater supplies in at least five States and in Canada. Very low concentrations have also been detected in surface waters throughout the U.S.

- **Breakdown in water:** In aquatic environments, microorganisms readily degrade 2,4-D. Rates of breakdown increase with increased nutrients, sediment load, and dissolved organic carbon. Under oxygenated conditions the half-life is 1 week to several weeks.
- **Breakdown in vegetation:** 2,4-D interferes with normal plant growth processes. Uptake of the compound is through leaves, stems, and roots. Breakdown in plants is by a variety of biological and chemical pathways. 2,4-D is toxic to most broad leaf crops, especially cotton, tomatoes, beets, and fruit trees.

Physical Properties:

- **Appearance:** 2,4-D is a white powder.
- **Chemical Name:** (2,4-dichlorophenoxy)acetic acid
- **CAS Number:** 94-75-7
- **Molecular Weight:** 221.04
- **Water Solubility:** 900 mg/L @ 25 C (acid)
- **Solubility in Other Solvents:** ethanol v.s.; diethyl ether v.s.; toluene s.; xylene s.
- **Melting Point:** 140.5 C
- **Vapor Pressure:** 0.02 mPa @ 25 C (acid)
- **Partition Coefficient:** 2.81
- **Adsorption Coefficient:** 20 (acid)

Exposure Guidelines:

- **ADI:** 0.3 mg/kg/day
- **MCL**: 0.07 mg/L
- **RfD:** 0.01 mg/kg/day
- **PEL:** 10 mg/m3 (8-hour)
- **HA**: Not Available
- **TLV**: Not Available

Basic Manufacturer:
Rhone-Poulenc Ag. Co.
P.O. Box 12014
2 T.W. Alexander Dr.
Research Triangle Park, NC 27709

- **Phone:** 919-549-2000
- **Emergency:** 800-334-7577

DISCLAIMER: The information in this profile does not in any way replace or supersede the information on the pesticide product labeling or other regulatory requirements. Please refer to the pesticide product labeling.

Triclopyr - (Trade name Renovate3®).

There are two formulations of triclopyr. It is the TEA formation of triclopyr that is registered for use in aquatic or riparian environments. Triclopyr, applied as a liquid, is a relatively fast-acting, systemic, selective herbicide used for the control of Eurasian watermilfoil and other broad-leaved species such as purple loosestrife. Triclopyr can be effective for spot treatment of Eurasian watermilfoil and is relatively selective to Eurasian watermilfoil when used at the labeled rate.

Many native aquatic species are unaffected by triclopyr. Triclopyr is very useful for purple loosestrife control since native grasses and sedges are unaffected by this herbicide. When applied directly to water, Ecology has imposed a 12-hour swimming restriction to minimize eye irritation.

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Imazapyr (Trade name Habitat®).

This systemic broad spectrum herbicide, applied as a liquid, is used to control emergent plants like spartina, reed canarygrass, and phragmites and floating-leaved plants like water lilies. Imazapyr does not work on underwater plants such as Eurasian watermilfoil. Although imazapyr is a broad spectrum, non-selective herbicide, a good applicator can somewhat selectively remove targeted plants by focusing the spray only on the plants to be removed.

Fluridone

Trade names for fluridone products include: Sonar® and Avast!®). Fluridone is a slow-acting systemic herbicide used to control Eurasian watermilfoil and other underwater plants. It may be applied as a pellet or as a liquid. Fluridone can show good control of submersed plants where there is little water movement and an extended time for the treatment. Its use is most applicable to whole-lake or isolated bay treatments where dilution can be minimized. It is not effective for spot treatments of areas less than five acres. It is slow-acting and may take six to twelve weeks before the dying plants fall to the sediment and decompose.

When used to manage Eurasian watermilfoil, fluridone is applied several times during the spring/summer to maintain a low, but consistent, concentration in the water. Although fluridone is considered to be a broad spectrum herbicide, when used at very low concentrations, it can be used to selectively remove Eurasian watermilfoil. Some native aquatic plants, especially pondweeds, are minimally affected by low concentrations of fluridone.

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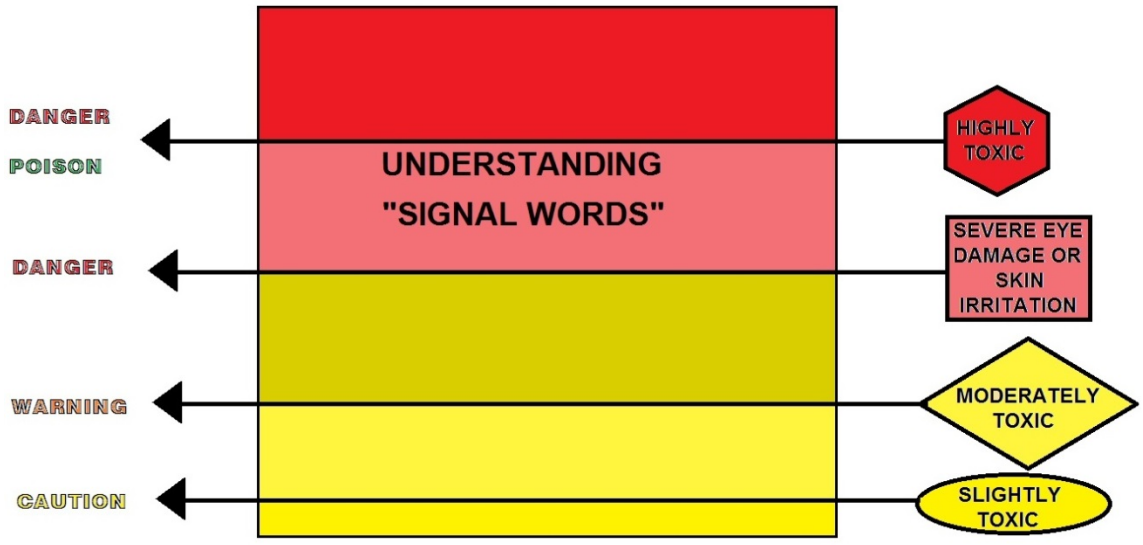


PESTICIDE LABEL SIGNAL WORD DIAGRAM

Year-Round Weed Management Strategies: A Summary

Prevention
Employ sanitary practices; prevent new weed infestations. Prevent weed shifts resulting from repeated:
• Cultivation (enhances perennial weeds).
• Mowing (enhances prostrate weeds).
• Herbicides (enhance tolerant weeds, new weed biotypes, new microorganisms that render herbicide inactive).

Identify and Map
• Use reference books to help identify annual and perennial weeds.
• Map and record infestations (weed abundance).
• Keep yearly records.

Prioritize Weeds (develop thresholds)
• Highly competitive weeds (control).
• Moderately competitive weeds (suppress).
• Low growing or noncompetitive weeds (don't worry).

List Controls
• Your experience.
• Local experts.
• Published information.
• Learn strengths and weaknesses of each control method.

Design Weed Management Program
• Select fields or garden area with manageable weed species.
• Consider environmental aspects: Erosion potential, surrounding water, high-value vegetation, or urban and/or recreational areas.
• Consider costs, equipment, skills, precision timing, and other factors needed to achieve results.
• Develop year-round weed management strategies involving combinations of weed control practices.

Evaluate Results
• Evaluate weed management programs.
• Continue mapping weeds for future reference.
• Modify practices as weeds shift because of repeated practices.

The best method for weed control is a good start or foundation. Here we have black mesh plastic that allows the water to perk in to the ground and prevent weed roots to take a firm hold, and annual draining of the pond helps kill off weeds. Problem is most of us cannot drain our pond unless there is an emergency.

Biological

Grass carp will seldom control aquatic vegetation the first year they are stocked. They will consume nitella. Grass carp stocking rates to control nitella are usually in the range of 7 to 15 per surface acre.

Tilapia will consume nitilla but are a warm water species that cannot survive in temperatures below 55° F. Therefore, tilapia usually cannot be stocked before mid-April or May and will die in November or December. Recommended stocking rates are 15 to 20 pounds of mixed sex adult Mozambique tilapia (Oreochromis mossambicus) per surface area. Tilapias are often not effective for vegetation control if the pond has a robust bass population due to intense predation.

Understanding Aquatic Toxicology

Aquatic toxicology is the study of the effects of environmental contaminants on aquatic organisms, such as the effect of pesticides on the health of fish or other aquatic organisms. A pesticide's capacity to harm fish and aquatic animals is largely a function of its (1) toxicity, (2) exposure time, (3) dose rate, and (4) persistence in the environment.

Toxicity of the pesticide refers to how poisonous it is. Some pesticides are extremely toxic, whereas others are relatively nontoxic. Exposure refers to the length of time the animal is in contact with the pesticide. A brief exposure to some chemicals may have little effect on fish, whereas longer exposure may cause harm.

The dose rate refers to the quantity of pesticide to which an animal is subjected (orally, dermally, or through inhalation). A small dose of a more toxic chemical may be more damaging than a large dose of a less toxic chemical. Dosages can be measured as the weight of toxicant per unit (kilogram) of body weight (expressed as mg pesticide/kg of body weight) or as the concentration of toxicant in the water or food supply (usually expressed as parts per million, ppm or parts per billion, ppb).

A lethal dose is the amount of pesticide necessary to cause death. Because not all animals of a species die at the same dose (some are more tolerant than others), a standard toxicity dose measurement, called a Lethal Concentration 50 (LC50), is used. This is the concentration of a pesticide that kills 50% of a test population of animals within a set period of time, usually 24 to 96 hours.

Hazard ratings ranging from minimal to super toxic and LC50s for commonly used insecticides, herbicides, and fungicides are presented in Tables 3, 4 and 5. For example, the 24-hour LC50 of the insecticide permethrin to rainbow trout is 12.5 ppb. This means that one-half of the trout exposed to 12.5 ppb of permethrin died within 24 hours, indicating super toxicity of this pesticide to trout.

Hazard Ratings	
Toxicity	**LC50(mg/l)**
Minimal	>100
Slight	10 - 100
Moderate	1 - 10
High	0.1 - 1.0
Extreme	0.01 - 0.1
Super	< 0,01

Exposure of fish and other aquatic animals to a pesticide depends on its biological availability (bio-availability), bio-concentration, bio-magnification, and persistence in the environment.

Bioavailability refers to the amount of pesticide in the environment available to fish and wildlife. Some pesticides rapidly break down after application. Some bind tightly to soil particles suspended in the water column or to stream bottoms, thereby reducing their availability. Some are quickly diluted in water or rapidly volatize into the air and are less available to aquatic life.

Bioconcentration is the accumulation of pesticides in animal tissue at levels greater than those in the water or soil to which they were applied. Some fish may concentrate certain pesticides in their body tissues and organs (especially fats) at levels 10 million times greater than in the water.

Bio-magnification is the accumulation of pesticides at each successive level of the food chain. Some pesticides bio-accumulate (buildup) in the food chain. For example, if a pesticide is present in small amounts in water, it can be absorbed by water plants which are, in turn, eaten by insects and minnows. These also become contaminated. At each step in the food chain the concentration of pesticide increases. When sport fish such as bass or trout repeatedly consume contaminated animals, they bio-concentrate high levels in their body fat. Fish can pass these poisons on to humans.

Persistence of Pesticides
Persistence refers to the length of time a pesticide remains in the environment. This depends on how quickly it breaks down (degrades), which is largely a function of its chemical composition and the environmental conditions. Persistence is usually expressed as the "half-life" (T1/2) of a pesticide. Half-life is the amount of time required for half of the pesticide to disappear (the other half remains). Half-life of pesticides can range from hours or days, to years for more persistent ones.

Pesticides can be degraded by sunlight (photodecomposition), high air or water temperatures (thermal degradation), moisture conditions, biological action (microbial decay), and soil conditions (pH). Persistent (long-lasting) pesticides break down slowly and may be more available to aquatic animals.

Pesticide Formulations
The active ingredient (pesticide) is combined with other inert ingredients (carriers, solvents, propellants) to comprise the formulated pesticide product. In some cases the inert ingredients may cause concern for aquatic life. Pesticides may be purchased in solid (granules, powders, dusts) or liquid (water, oil sprays) form. A major concern in using either solid or liquid forms of pesticides is their misapplication.

Sub-lethal Effects
Not all pesticide poisonings result in the immediate death of an animal. Small "sub-lethal" doses of some pesticides can lead to changes in behavior, weight loss, impaired reproduction, inability to avoid predators, and lowered tolerance to extreme temperatures.

Fish in streams flowing through croplands and orchards are likely to receive repeated low doses of pesticides if continuous pesticide applications run-off fields. Repeated exposure to certain pesticides can result in reduced fish egg production and hatching, nest and brood abandonment, lower resistance to disease, decreased body weight, hormonal changes, and reduced avoidance of predators. The overall consequences of sub-lethal doses of pesticides can be reduced adult survival and lowered population abundance.

Sub-lethal Effects include:
- Weight Loss
- Low Diseases Resistance
- Sterility
- Reduced Egg Production
- Loss of Attention
- Low Predator Avoidance

Habitat Alteration
Pesticides can reduce the availability of plants and insects that serve as habitat and food for fish and other aquatic animals. Insect-eating fish can lose a portion of their food supply when pesticides are applied. A sudden, inadequate supply of insects can force fish to range farther in search of food, where they may risk greater exposure to predation.

How Fish are Exposed
Spraying herbicides can also reduce reproductive success of fish and aquatic animals. The shallow, weedy nursery areas for many fish species provide abundant food and shelter for young fish. Spraying herbicides near weedy nurseries can reduce the amount of cover and shelter that young fish need in order to hide from predators and to feed. Most young fish depend on aquatic plants as refuge in their nursery areas.

Aquatic plants provide as much as 80% of the dissolved oxygen necessary for aquatic life in ponds and lakes. Spraying herbicides to kill all aquatic plants can result in severely low oxygen levels and the suffocation of fish. Using herbicides to completely "clean up" a pond will significantly reduce fish habitat, food supply, dissolved oxygen, and fish productivity.

The landowner who sprays a weedy fence line with herbicides may unintentionally kill the trumpet vine on which hummingbirds feed and the honeysuckle that nourish deer and quail. Similarly, the landowner who unnecessarily sprays his water plants kills the plants that feed the insects that feed the fish that feed the farmer. Casual use of herbicides for lake or farm pond "beautification" may reduce fish populations.

Fish and aquatic animals are exposed to pesticides in three primary ways (1) dermally, direct absorption through the skin by swimming in pesticide-contaminated waters, (2) breathing, by direct uptake of pesticides through the gills during respiration, and (3) orally, by drinking pesticide-contaminated water or feeding on pesticide-contaminated prey. Poisoning by consuming another animal that has been poisoned by a pesticide is termed "secondary poisoning." For example, fish feeding on dying insects poisoned by insecticides may themselves be killed if the insects they consume contain large quantities of pesticides or their toxic byproducts.

Reducing the Risk: Prior to using a pesticide, consider the following:

1. Use a Pesticide Only When Necessary
    - Is the problem bad enough to justify the use of a toxic chemical? Are there alternative ways of treating the problem? Landowners should consider the costs and consequences of pesticide treatment relative to the problem.
2. Use Less Toxic Pesticides
    - One way to reduce the effects of pesticides on aquatic systems is to use those chemicals that are least poisonous to aquatic life. The tables presented at the end of this booklet give information about the relative toxicity of many of the agricultural pesticides. Select the least toxic material.
3. Use Safe/Sensible Application Methods
    - The first rule of responsible pesticide use is to read and then reread the pesticide label and follow the directions precisely. Label instructions sometimes can be confusing. If you don't understand the instructions, contact your Extension Agent, your supplier, or the pesticide company for more information.
    - Pay particular attention to warning statements about environmental hazards on the label. Look for: "This product is toxic to fish." If you see such a warning, consider another pesticide or an alternative control method.
    - Ensure that your application equipment is in good working condition. Check for leaks, replace worn parts, and carefully calibrate your equipment.
    - When preparing the pesticides for application, be certain that you are mixing them correctly.
    - Never wash spray equipment in lakes, ponds, or rivers. If you use water from natural ponds, lakes, or streams, use an antisiphon device to prevent backflow.

- If you are applying pesticides near water, check the label to find the recommended buffer zone. Buffer strip widths between the water and the treatment areas vary. Leave a wide buffer zone to avoid contaminating fish and aquatic animals.
- Store and dispose of unused chemicals and their containers according to the label instructions.
- Avoid pesticide drift into non-target areas, or applications during wet, windy weather that might promote runoff to non-target streams, ponds, or lakes. Spray on calm days, or early in the morning or evening when it is less windy.
- Pesticide applicators are liable for downstream fish kills and pesticide contamination.

Southern Watergrass

Buttonbush

Topic 7 Weed Management and Control Section
Answers at the rear of Glossary

Fill-in-the-blank

1. Active ingredient (ai) – The chemical in a herbicide formulation primarily responsible for its _____and which is identified as the active ingredient on the product label.

Mechanical Control

2. A combination of _____can be very effective on woody invaders like trees or shrubs. The woody plant can be cut with hand ax or saw and the stump wiped with 2,4-D, Roundup™, or some other herbicide.

3. Normally, biological control of newly invasive species is not practical and should not be considered. Identifying and developing _____can take years, and small infestations often can't sustain on the few plants present during the initial infestation.

4. _____is necessary following mechanical or chemical control. Digging and chopping cause soil disturbance and desired plants need to be reestablished before the invader can get a foothold.

Cultural Control

5. Cultural control, the establishment of competitive and desired vegetation, prevents or slows down invasion by weedy species and is a key component of successful weed management. Weeds are typically _____and readily invade disturbed sites.

6. Diquat dibromide is _____and plant growth regulator, causing injury only to the parts of the plant to which it is applied.

7. There are many forms or derivatives of 2,4-D including esters, amines, and salts. Unless otherwise specified, this document will refer to the acid form of 2,4-D. 2,4-D, a chlorinated phenoxy compound, functions as a _____and is used to control many types of broadleaf weeds.

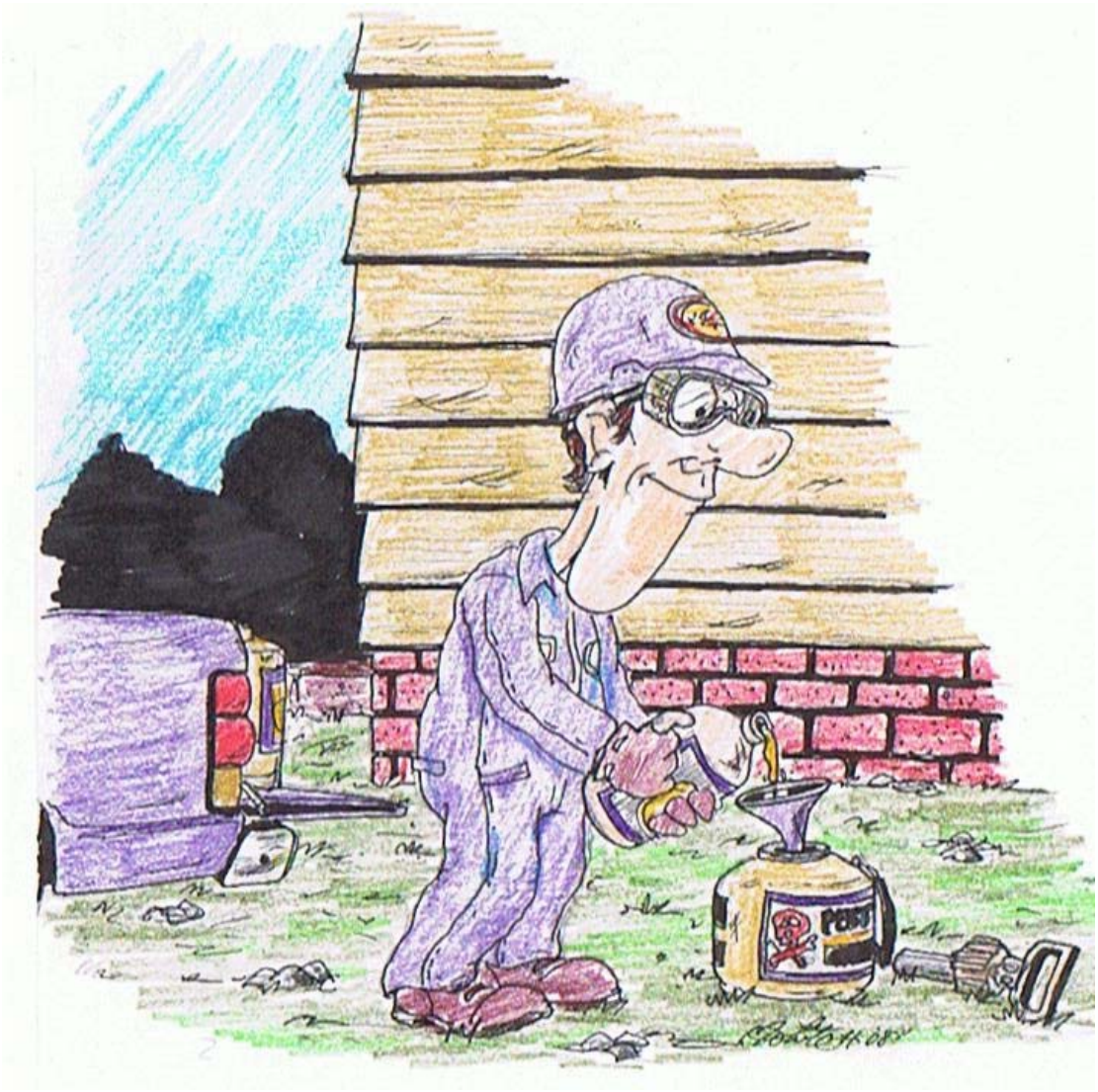
Imazapyr (Trade name Habitat®).

8. Although imazapyr is a broad spectrum, non-selective herbicide, a good applicator can somewhat selectively remove _____by focusing the spray only on the plants to be removed.

Persistence of Pesticides

9. _____is usually expressed as the "half-life" (T1/2) of a pesticide.

10. _____of pesticides can range from hours or days, to years for more persistent ones.



ALWAYS READ THE PRODUCT LABEL FOR DIRECTIONS, CURRENT RESTRICTIONS AND WARNINGS. Some considerations may include potential contamination of domestic water supplies and waiting periods for watering livestock, eating fish, swimming, and irrigation.

1. Although they provide good control when applied correctly, herbicides may also harm desirable organisms if used improperly. The decay of large amounts of dead plant material following chemical application can lower dissolved oxygen to lethal levels for fish. For this reason, it is recommended to treat only one-third of the plants at seven to ten day intervals until control is obtained. Chemical control can be very expensive and it isn't permanent; continuous re-treatment will be necessary. Please remember that the long-term effects of most herbicides on the environment are not well known.
2. Duckweed and watermeal grow very fast. For this reason, chemical control should begin as soon as the plants appear in the spring.

Topic 8 Introduction to Wetlands Section

Aquatic plants are listed in four groups according to the habitats in which they are usually found. The four groups are algae, floating weeds, emersed (above water) weeds and submersed (underwater) weeds. (Figure 1). To identify the weed in question, first decide in which group it belongs, turn to that section, and use the illustrations and descriptions to make your decision. Remember, only the more common weeds are described.

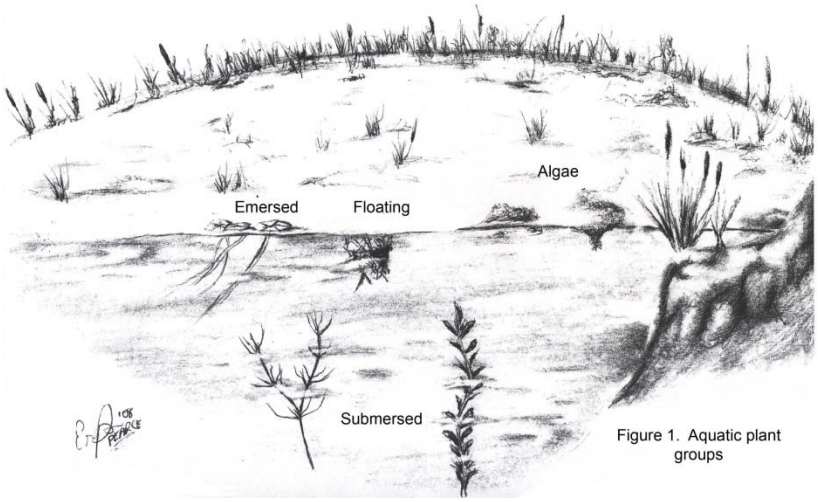


Figure 1. Aquatic plant groups

Algae
These plants occur in most waters exposed to sunlight. Shape and size vary from microscopic single-celled plants to branched-coarse plants resembling submerged aquatic weeds. Algae, unlike other aquatic plants, do not produce flowers or seeds. Based upon size and shape, algae can be divided into three groups: microscopic (planktonic) algae, filamentous algae, and stoneworts.

Microscopic Algae
Microscopic (planktonic) algae are single or multiple-celled plants that cannot be identified without the aid of magnification (Figure 2). Specific identification is usually not essential for control. Rather, it is important to recognize the plant group and not the individual species. Most of the microscopic algae respond to the same control measures. They occur in almost all ponds.

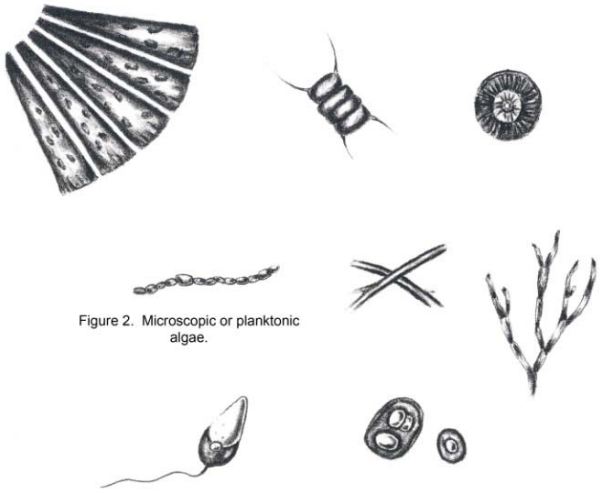


Figure 2. Microscopic or planktonic algae.

These algae are generally beneficial to ponds. They are the beginning of the food chain, converting nutrients from the water into usable food for insects and fish. Through photosynthesis, they provide dissolved oxygen, essential to life in the pond.

Pond fertilization promotes the growth of microscopic algae as evidenced by the green color of the water (Figure 3). There is rarely a need to control these plants in a pond; however, excessive blooms can lead to oxygen depletion and fish kills. Excessive blooms are usually the result of over-fertilization or organic pollution.

A few species, especially some of the blue-green algae such as Microcystis, can cause fish kills and animal and human health problems. Blooms of these algae occur occasionally and are usually associated with organic pollution. Masses of these plants appear rapidly and make the water seem like a "soupy" bright green mass on the downwind side of the pond.

These plants also give off a foul sewage-like odor and can give an off-flavor to fish caught from the pond. Fish affected by the toxins of this plant act drugged and may convulse. Fish usually show these symptoms only during the daylight hours. A rapid and complete fish kill, although rare, may occur.

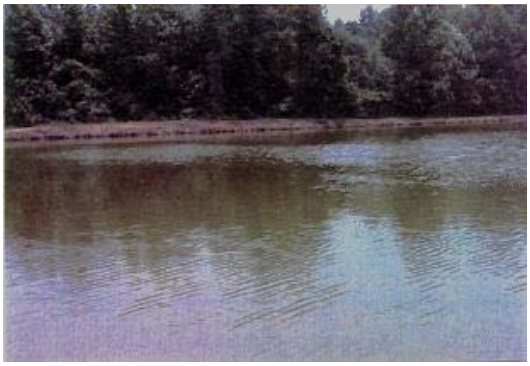


Figure 3. Microscopic (planktonic) algae.

Filamentous Algae

Unlike microscopic algae, filamentous algae are frequently a problem in pond management and are usually visible to the naked eye as a floating mat of thread-like filaments often called "pond moss" (Figure 4). They usually begin growth on the pond bottom in shallow water, later float to the surface and may completely cover the pond surface.

Figure 4. Filamentous algae.

Except for a few species, all filamentous algae control methods are similar. As with microscopic algae, it is more important to recognize the plant group and not the individual species.

One group of widespread algae which is difficult to control is *Pithophora* spp. *Pithophora* resembles a mass of wet, green wool (Figure 5).

Figure 5. *Pithophora*.

Stoneworts
This group of algae is quite often confused with underwater aquatic plants because it is attached to the pond bottom. No part of the plant extends above the water surface. Stoneworts do not produce flowers or seeds.

Chara *(Chara* spp*.)*
Chara has a distinctive musky odor when crushed (Figure 6). It is usually grey-green and has a rough texture caused by calcium deposits on the plant. This branched algae has whorled thread size "leaves" and the plant is anchored to the bottom mud. It occurs throughout the U.S. and is more commonly found in hard water areas.

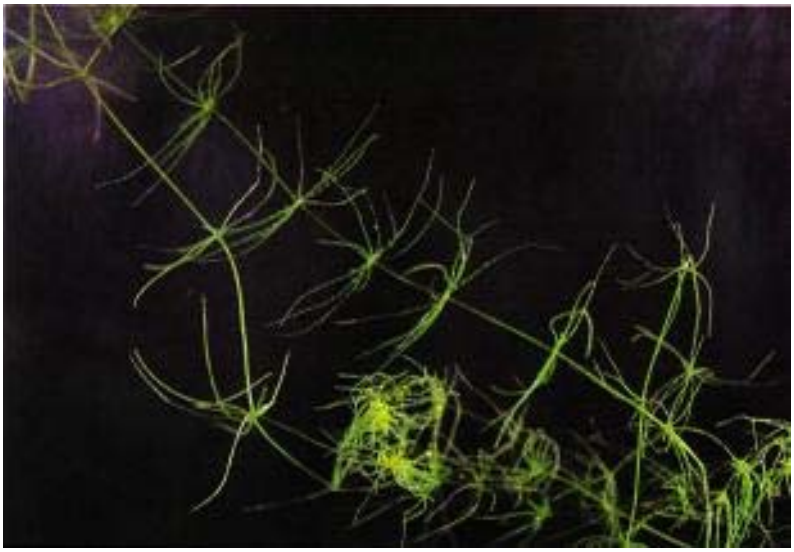


Figure 6. Chara.

Nitella (*Nitella* spp.)

Nitella is similar in appearance to Chara. However, the plant is dark green, does not have a musky odor, and does not have the texture of chara. It is more common in acid or soft water areas.

Nitella

Stoneworts are branched multicellular algae that are often confused with submerged flowering plants. However, stoneworts have no flower and will not extend above the water surface. Nitella has no odor and are soft to the touch, unlike Chara. Stoneworts are light to dark green in color with forked, bushy branches 1/16 to 1/8 inches in diameter.

Submerged portions of all aquatic plants provide habitats for many micro and macro invertebrates. These invertebrates in turn are used as food by fish and other wildlife species (e.g. amphibians, reptiles, ducks, etc.). After aquatic plants die, their decomposition by bacteria and fungi provides food for many aquatic invertebrates. Stoneworts have no known direct food value to wildlife.

Nitella can be removed by raking or seining. Fertilization to produce a phytoplankton or algal "bloom" prevents the establishment of most bottom rooted aquatic weeds and produces a strong food chain to the pond fish.

Non-toxic dyes or colorants prevent or reduce aquatic plant growth by limiting sunlight penetration, similar to fertilization. **Aquashade** is an example of non-toxic dye and other products are available. However, dyes do not enhance the natural food chain and may suppress the natural food chain of the pond.

General Algae Control

Algae problems are usually caused by an overabundance of nutrients (nitrogen and phosphorous) in the pond. From the moment a pond is built, it becomes a settling basin for nutrients washing in from the land that drains into it (the pond's watershed).

As a water body ages, the more nutrients it accumulates and the more susceptible it is to algae problems. Runoff from fertilized fields, lawns and pastures, or from feedlots, septic tanks and leach fields accelerates nutrient loading and algae growth in the pond. If the pond is old and has become shallow due to accumulation of black muck on the bottom, it may be necessary to drain, dry, and deepen the pond. Excavated material should be removed from the pond's watershed.

Planning
Establishing and maintaining a 100 foot or wider buffer strip of grass and trees around the pond's edge will help filter excess nutrients from runoff water. This combined with a 3:1 grade at the shoreline will reduce the opportunities for macrophytic algae and other rooted plants to grow to nuisance levels in the lake.

The construction of small (4-6feet in depth) silt retention ponds in the watershed will help settle out nutrients before they can enter the lake. Localized nutrient inputs from feedlots or other sources may be avoided by tiling, or by constructing a water diversion terrace below the nutrient source to direct its runoff away from the pond.

Fencing livestock from the pond's edge and watering them from a tank below the dam is also a helpful protective measure. The Natural Resource Conservation Service (NRCS) or Pesticide Regulation Agency office in your area can provide information on these and other water quality practices.

Mechanical Control
Mechanical control means removing the vegetation by hand and through the use of mechanized equipment. Mats of filamentous algae may be removed with a rake, seine, screen wire or similar devices; however, this control method is very labor intensive and provides only temporary control. In some instances, the algae may seem to grow as fast as it is pulled out.

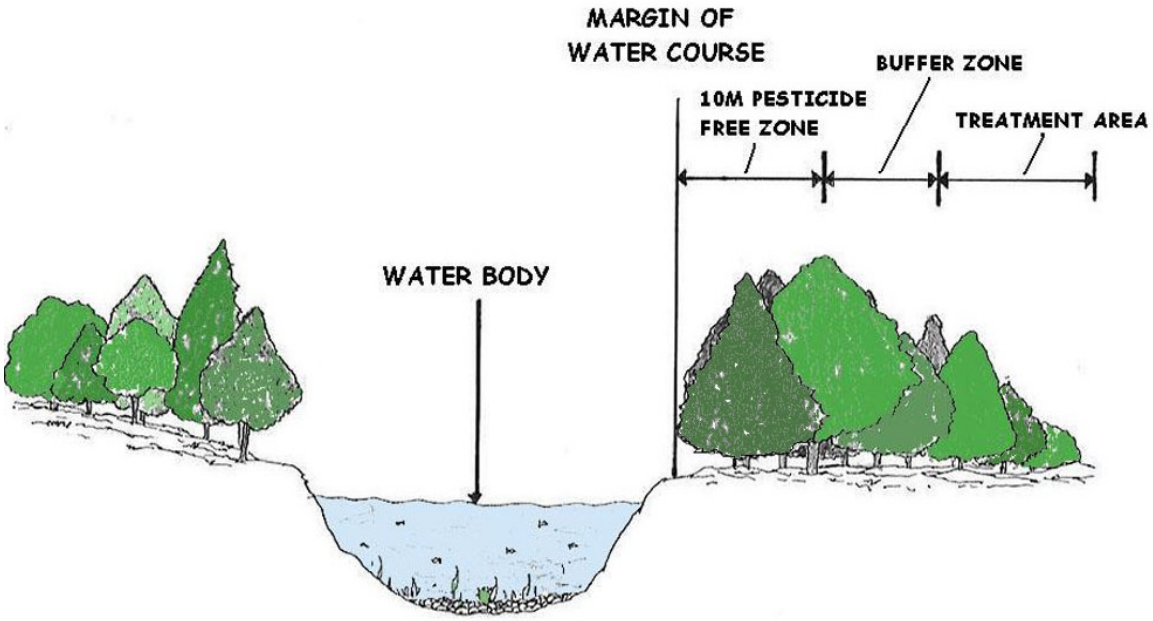
Mechanical control is practical when used in conjunction with chemical control methods or as a maintenance treatment around swimming or fishing areas for an occasional special event.

Algae removed from the pond by mechanical means should be deposited below the pond's dam to ensure that nutrients tied up in the vegetation do not re-enter the pond.

Biological Control
Biological control is the use of biological agents (fish, pathogens, insects, plants...) to combat unwanted species, in natural, recreational, agricultural or other situations.

One example of biological control is stocking grass carp (Ctenopharyngodon idella) to control aquatic vegetation. Grass carp are not very effective at controlling filamentous or macrophytic algae, except at very high densities. Grass carp do not control planktonic algae.

Chemical Control
DIRECTIONS, RESTRICTIONS AND WARNINGS
ALWAYS READ THE PRODUCT LABEL FOR DIRECTIONS, CURRENT RESTRICTIONS AND WARNINGS. Before using chemicals, you should consider potential contamination of domestic water supplies and the waiting periods for watering livestock, eating fish, swimming, and irrigation. Algae control with chemicals works best when the water temperature is above 60° Fahrenheit and algae mats are broken up while the chemical is being applied.



Chemicals are applied to ponds and lakes to control weeds; to control fish diseases; to eliminate un-desirable fish; to control undesirable insects and aquatic invertebrates and to correct undesirable water quality problems. Pond owners are often confused by terminology, units of measure, and formulations. This confusion makes it difficult to select the right chemical, to calculate the proper amount to be applied, and to apply it to the pond in a correct and safe manner.

To avoid oxygen depletion and a possible fish kill, avoid treating when the water temperature is above 80° Fahrenheit and treat only 1/4 to 1/3 of the vegetation at a time.

Allow ten days to two weeks between consecutive treatments. Chemicals do not provide permanent control, so repeated treatments are usually necessary to keep algae at desired levels. Please remember that the long term effects of most herbicides on the environment are not well known

Currently recommended herbicides for algae control. Though these chemicals are recommended and have proven reliable, other chemicals may be suitable for aquatic weed control.

This course contains EPA's federal rule requirements. Please be aware that each state implements pesticide regulations that may be more stringent than EPA's regulations and these frequently are changed. Check with your state environmental/pesticide agency for more information.

Algaecides

Cutrine Plus (Liquid)	Cutrine Plus (Granular)	Copper Sulfate (Granular)

All three are approved in most States for the control of Planktonic Algae.
All three are approved in most States for the control of Filamentous Algae.
All three are approved in most States for the control of Macrophytic Algae.

Local farm supply stores often carry, or will order, these herbicides. For alternate sources of chemicals, a copy of the product's label, or clarification of this course section, contact your Fisheries Regional office or the pesticide agency website.

Determination of Acre-Feet to Calculate Total Amount of Herbicide Needed

If the acreage of the area to be treated is known, the number of acre-feet can be determined by multiplying the number of acres by the average depth (average depth = 1/3 of the maximum depth). For example: A two acre area is to be treated and has an average depth of three feet. The volume of the water is six acre-feet.

2 acres x 3 feet (average depth) = 6 acre-feet

If the dosage of herbicide recommended is 2 gallons of herbicide per acre-foot, the total herbicide needed would be twelve gallons.

6 acre-feet x 2 gal/acre-foot = 12 gallons (total herbicide needed)

If the number of acres is not known, it can be estimated by measuring the number of square feet and dividing by 43,560. The number of square feet in many cases can be closely approximated by multiplying the average width in feet by the average length in feet. For example: A shoreline area is to be treated. The weeded area is 500 feet long and averages 10 feet wide.

The total surface area is 5,000 square feet or 0.115 acres.

10 feet x 500 feet = 5,000 square feet
5,000 square feet .
43,560 (square feet in an acre)

The average depth of water in this shoreline area is 1 foot. The total acre-feet is 0.115.

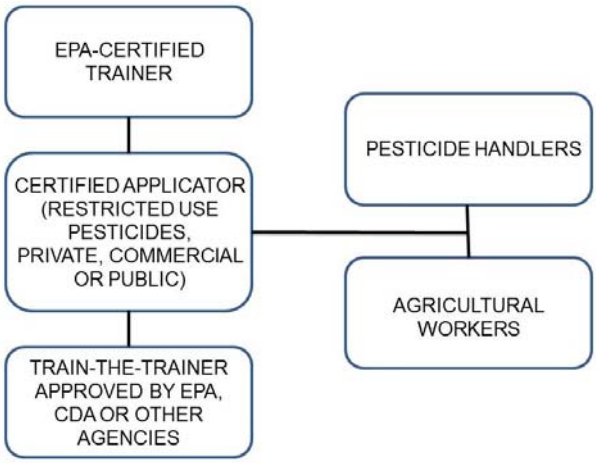
0.115 acres x 1 foot (average depth) = 0.115 acre-feet

If we assume that 4 gal/acre-foot was the recommended dosage, then 0.46 gallons of herbicide would be needed.

4 gal/acre-foot x 0.115 (acre feet) = 0.46 gallons (total herbicide needed) = 0.115 acres

Aquatic Herbicide Sources

Athea Laboratories Inc., P.O. Box 23926 Milwaukee, WI 53223.
Albaugh Inc., 1517 N. Akeny Blvd. Suite A, Ankeny, IA 50021
Applied Biochemists, 5300 W. County Line Road, 96 North, Mequon, WI 53092
Aquacide Co., 1627 9th St., White Bear Lake, MN 55110, (800)328-9350
Aquashade Inc., 6120 W. Douglas Ave., Milwaukee, WI 53218
A & V Incorporated, N62 W22632 Village Drive, Sussex, WI 53089, (205) 288-3185
Chem One Corp., 15150 Sommermeyer, Houston, TX 77041-5308
ELF Atochem North America, 2000 Market St., Philadelphia, PA 19103, (205) 288-3185
Frank Miller & Sons Inc., 13831 S. Emerald Ave., Chicago, IL 60627
Great Lakes Biochemical Co. Inc., 6120 W. Douglas Ave., Milwaukee, WI 53218
Griffin Corporation, P.O. Box 1847, Valdosta, GA 31603, (912) 244-7954
Helena Chemical Co., 6075 Poplar Ave., Suite 500, Memphis, TN 38119.
I. Schneid Inc., 1429 Fairmont Ave., N.W., Atlanta, GA 30381.
Monsanto Agricultural Company, 700 Chesterfield Parkway North, St. Louis, MO, 631987 or 800 N. Lindbergh Blvd., St. Louis, MO 63167, (919) 556-7124
NCH Corporation. 2727 Chemsearch Blvd., Irving, TX 75062.
PBI/Gordon Corporation, 1217 W. 12th Street, P.O. Box 4090, Kansas City, MO 64101, (816) 421-4070
Phelps Dodge Refining Corporation, Box 20001, El Paso TX, 79998.
Qualis Inc., 4600 Park Ave., Des Moines, IA 50321
Riverdale Chemical Co., 425 W. l94th St., Glenwood, IL 60425, (317) 780-1944
Rhone-Poulenc Ag Company, P.O. Box 12014, 2 T. W. Alexander Drive, Research Triangle Park, NC 27709, (919) 859-6070
SEPRO Corporation, 11550 N. Meridian St., Suite 200, Carmel, IN 46032, (800)419-7779
State Chemical Manufacturing Co., 3100 Hamilton Ave., Cleveland, OH 44114.
Uniroyal Chemical Co., Inc., 74 Amity Road, Bethany, CT 06524, (919) 848-9675
Zeneca Agricultural Products, Box 15458 Wilmington, DE. 19850-5458 or 1800 Concord Pike, Wilmington, DE 19897, (800) 759-2500



Floating Aquatic Weed Section

Plants in this group float in or on the water and obtain nutrients from the water rather than the soil. They are rarely attached to the pond bottom.

Duckweeds (Family-*Lemnaceae*)

Duckweeds are small floating plants which at a distance can be mistaken for algae (Figures 7, 8). Depending upon the species, duckweeds may range in size from microscopic to about 1 inch in diameter. Another plant group similar to duckweed is waterfern (Azolla spp.) Leaves of these plants are 0.1 to 0.4 inches wide and overlap one another as scales on a fish.

Figure 7. Duckweed

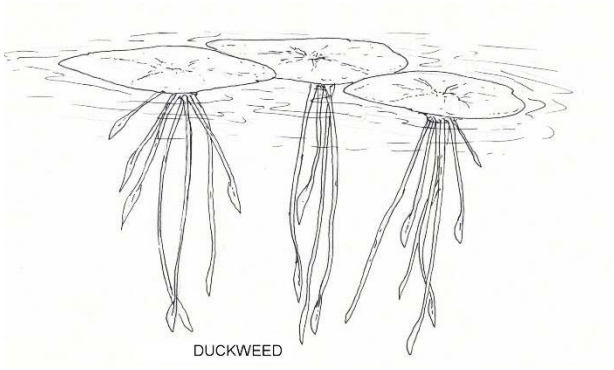


Figure 8. Duckweeds.

Duckweed and Watermeal Control

Duckweed and watermeal are fast growing aquatic plants that can sometimes reach nuisance densities in less than one month. Small amounts of these plants will not harm a good pond, but dense growths can block sunlight, reduce oxygen concentrations, and upset the natural pond balance.

Mechanical, biological, and chemical control of aquatic plants are options available to the pond owner. A few duckweeds will not hurt a lagoon, but if the duckweeds become so dense that they block out the sunlight, they can be detrimental to the healthy balance that the lagoon needs to function properly.

The dense cover will reduce the light, killing the algae, thus reducing the oxygen level in the lagoon. This may cause an odor problem and the duckweed would need to be controlled. These weeds may be controlled by chemical or physical means. Chemicals work best, but either method may be short lived as one duckweed can reproduce to cover 10 square feet in one day.

Eagre - mix 2 ounces of Eagre with 2 ounces of Cide-Kick per gallon of water in a tank sprayer.

Mechanical Control

1. Seining with small mesh nets or with window-screen material can reduce coverage of free-floating plants in a small pond. Since free-floating plants reproduce so quickly, mechanical methods are only temporary solutions. However, temporary control may be all you need to enjoy a fishing trip or a swimming party.

2. Dense growth of duckweed or watermeal is usually linked to high levels of nutrients in the water. Nutrients like nitrogen and phosphorous can come from waterfowl waste, septic tank seepage, feedlot runoff, uneaten fish food, or fertilizer washed off fields, pastures or lawns.

Eliminating or diverting these nutrient sources will reduce the chance of having problems with duckweed or watermeal. If the pond is old and has become shallow due to accumulation of black muck on the bottom, it may be necessary to drain, dry, and deepen the pond. The black muck is a storehouse of nutrients that fuel the excessive growth of aquatic plants. All excavated material should be removed from the pond's watershed.

Above, we have an example of simple mechanical removal method of using a heavy rake with a rope tied to it. Toss the rake twenty feet in the pond, let the rake sink, and reel it in. Good method to remove pondweeds and nitella.

Biological Control

The grass carp (*Ctenopharyngodon idella*), or white amur, is a plant eating Asian member of the minnow family used to control certain species of aquatic plants. Grass carp may eat some duckweed and watermeal, but these plants reproduce so quickly that they can cover a one acre pond in two months. For this reason, grass carp are generally not an effective control measure. See the Grass Carp Section in the rear for more information.

Chemical Control

1. **ALWAYS READ THE PRODUCT LABEL FOR DIRECTIONS, CURRENT RESTRICTIONS AND WARNINGS.** Some considerations may include potential contamination of domestic water supplies and waiting periods for watering livestock, eating fish, swimming, and irrigation.
2. Although they provide good control when applied correctly, herbicides may also harm desirable organisms, if used improperly. The decay of large amounts of dead plant material following chemical application can lower dissolved oxygen to lethal levels for fish. For this reason, it is recommended to treat only one-third of the plants at seven to ten day intervals until control is obtained. Chemical control can be very expensive and it isn't permanent; continuous re-treatment will be necessary.
Please remember that the long-term effects of most herbicides on the environment are not well known.
3. Duckweed and watermeal grow very fast. For this reason, chemical control should begin as soon as the plants appear in the spring.

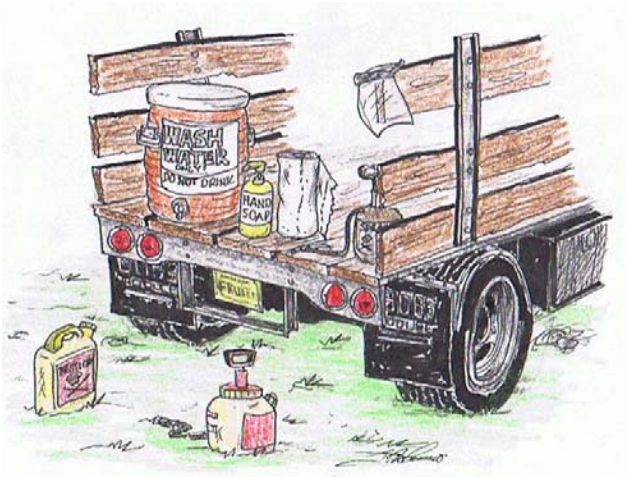
Currently recommended herbicides for Duckweed and Watermeal control and their suggested retail prices. Though these chemicals have been tested and have proven reliable other chemicals may be suitable for aquatic weed control.

Reward and Sonar-AS Reward Weedtrine-D Cutrine Plus Liquid all four are approved for Duckweed *(Lemna spp.) See rear section form more information*
Reward and Sonar-AS Reward Weedtrine-D Cutrine Plus Liquid all four are approved for Watermeal *(Wolffia spp.) See rear section form more information*
Minimum Quantity Cutrine Plus Available 1 pint, 1 quart, 1 gal. and 1 gallon.

Pesticides are categorized according to their target use. The three major groups of pesticides are: herbicides (weed control), insecticides (insect control), and fungicides (disease control).

Plant Reproduction Key Words (See Glossary)

- Budding
- Fragmentation
- Rhizomes
- Tubers
- Spores
- Seeds

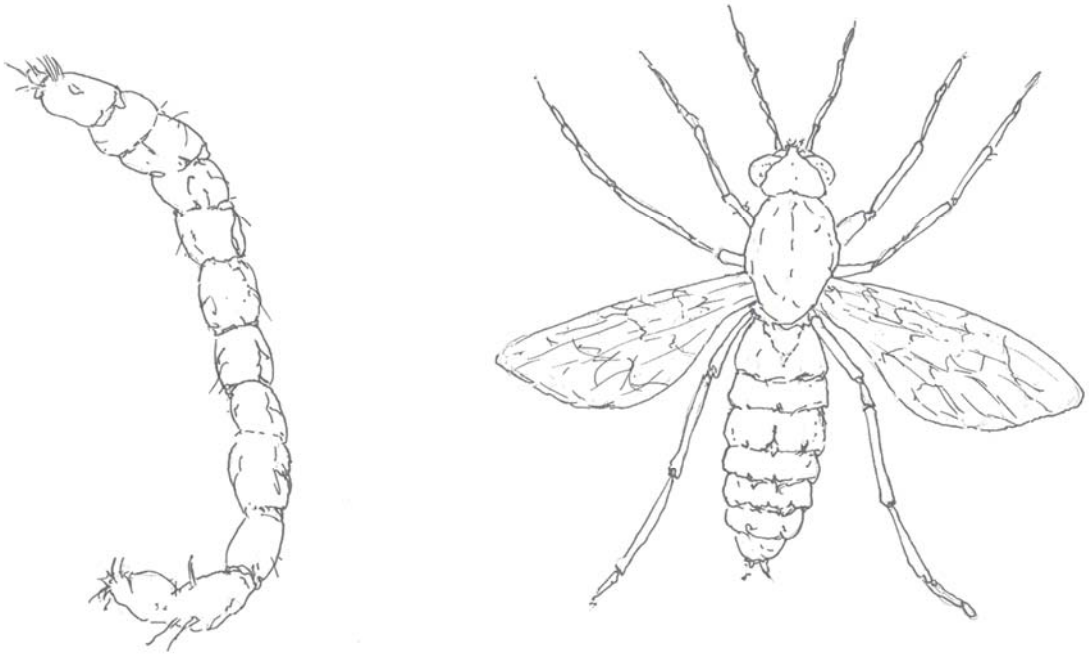


Herbicide Use for Duckweed and Watermeal

When using Reward, Weedtrine-D, or Reward/Cutrine Plus Liquid, the following recommendations should be followed:
1. Add a non-ionic surfactant at the rate of 3/4 ounces per gallon of water.
2. Use a fine spray when spraying the vegetation.
3. Do not treat when the pond is muddy.
4. Treat when the water surface is calm.
5. Treat any Duckweed that may be washed up on the bank.

Mix at a rate of 1/3 Cutrine Plus to 2/3 Reward. Dilute this solution at the rate of one part of mix to fourteen parts of water (one quart of solution to 3.5 gallons of water). Add 2.6 ounces of non-ionic surfactant. This quantity will treat 1/4 acre of water.

Local farm supply stores often carry, or will order, these herbicides. For alternate sources of chemicals, a copy of a product label or clarification of this course section, check with your Fisheries Regional office, Game and Fish or State Pesticide Agency office.



BITING MIDGES

Water Hyacinth (*Eichhornia crassipes*)

Water hyacinths are quite variable in size, and may range from 3 to 36 inches in height (Figure 9). Flowers may be blue, violet, or white and are quite showy. They are occasionally found rooted to the bottom. The plants are a serious problem along coastal areas.

Figure 9. Water hyacinth.

Description and Variation

Water hyacinth (Eichornia crassipes) is a member of the pickerelweed family (Pontederiaceae). The plants vary in size from a few centimeters to over a meter in height. The glossy green, leathery leaf blades are up to 20 cm long and 5-15 cm wide and are attached to petioles that are often spongy-inflated. Numerous dark, branched, fibrous roots dangle in the water from the underside of the plant. The inflorescence is a loose terminal spike with showy light-blue to violet flowers (flowers are occasionally white). Each flower has 6 bluish-purple petals joined at the base to form a short tube. One petal bears a yellow spot. The fruit is a three-celled capsule containing many minute, ribbed seeds.

Economic Importance

Water hyacinth is listed as one of the most productive plants on earth and is considered the world's worst aquatic plant. It forms dense mats that interfere with navigation, recreation, irrigation, and power generation.

These mats competitively exclude native submersed and floating-leaved plants. Low oxygen conditions develop beneath water hyacinth mats and the dense floating mats impede water flow and create good breeding conditions for mosquitoes. Water hyacinths are a severe environmental and economic problem in all of the gulf coast states and in many other areas of the world with a sub-tropical or tropical climate. This species has rapidly spread throughout inland and coastal freshwater bays, lakes, and marshes in the United States and in other countries.

With the increasing popularity of water gardening and home ponds, water hyacinth is now sold by many nurseries for its unusual appearance, attractive flowers, and ability to remove nutrients from the water.

Water hyacinth is thought to be cold-sensitive and unable to survive temperatures below 20°F.

Geographic Distribution
Water hyacinth originated in tropical South America, but has become naturalized in many warm areas of the world: Central America, North America (California and southern states), Africa, India, Asia, Australia, and New Zealand.

Habitat
Water hyacinths grow over a wide variety of wetland types from lakes, streams, ponds, waterways, ditches, and backwater areas. Water hyacinths obtain their nutrients directly from the water and have been used in wastewater treatment facilities. They prefer and grow most prolifically in nutrient-enriched waters. New plant populations often form from rooted parent plants, wind movements and currents help contribute to their wide distribution. Linked plants form dense rafts in the water and mud. In the Pacific Northwest, water hyacinth is planted outdoors in ponds and in aquaria, but it is not considered winter hardy, except under special conditions.

The fibrous root system of water hyacinth provides nesting habitat for invertebrates and insects. Leaf blades and petioles are occasionally used by coots. However, whatever benefits this plant provides to wildlife are greatly overshadowed by the environmental invasiveness of this noxious species.

History
It is believed that the water hyacinth was first introduced into the United States at the World's Industrial and Cotton Centennial Exposition of 1884-1885 in Louisiana. A Florida visitor to the Exposition apparently returned home with water hyacinth plants and subsequently released them into the St. Johns River. From there it spread rapidly to neighboring states.

Reproduction
Water hyacinth reproduces sexually by seeds and vegetatively by budding and stolen production. Daughter plants sprout from the stolons and doubling times have been reported of 6-18 days. The seeds can germinate in a few days or remain dormant for 15-20 years. They usually sink and remain dormant until periods of stress (droughts). Upon re-flooding, the seeds often germinate and renew the growth cycle.

Response to Herbicides
The use of herbicides to control water hyacinth is common. Westerdahl and Getsinger report excellent control of water hyacinth by the use of the aquatic herbicides 2,4-D, diquat, and a combination of diquat and complexed copper. Fair control of water hyacinth is obtained with endothall dipotassium salt, endothall dipotassium salt and complexed copper, endothall dimethylalkylamine salts, and glyphostate. Complexed copper may be allowed depending on existing sediment conditions.

Chemical
The active ingredients that have been successful in treating water hyacinth include 2,4-D (E), diquat (E), triclopyr (E), rodeo (G), and imazapyr (E). E = excellent, G = good

Reward is a liquid diquat formulation that has been effective on water hyacinth. It is a contact algaecide and herbicide. Contact herbicides act quickly and kill all plant cells that they contact. A non-ionic aquatically registered surfactant (see the label) will have to be added to the Reward solution for good results.

Renovate is a liquid triclopyr formulation that is effective on water hyacinth. It is a selective broadleaf, systemic herbicide. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides. An aquatically registered surfactant (see the label) will improve the effectiveness of triclopyr.

Rodeo, **Aquamaster**, **Eraser AQ**, **Touchdown Pro**, and **AquaNeat** are liquid glyphosate formulations and have been effective on water hyacinth. These are broad spectrum, systemic herbicides. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides. An aquatically registered surfactant (see the label) will have to be added to the glyphosate solution for good results.

Habitat contains the active ingredient, imazapyr, which inhibits the plant enzyme AHAS (acetohydroxyaced synthase). Habitat is a systemic herbicide that is effective on post-emergent floating and emergent aquatic vegetation. Imazapyr is effective at low-volume rates and does not contain heavy metals, organochlorides or phosphates, making it safe to humans and livestock. Habitat requires the use of a spray adjuvant when applying on post-emergent vegetation.

One danger with any chemical control method is the chance of oxygen depletion after the treatment, caused by the decomposition of the dead plant material.

Oxygen depletions can kill fish in the pond. If the pond is heavily infested with weeds it may be possible (depending on the herbicide chosen) to treat the pond in sections and let each section decompose for about two weeks before treating another section. Aeration, particularly at night, for several days after treatment may help control the oxygen depletion.

Response to Mechanical Methods
Mechanical controls such as harvesting have been used for nearly 100 years in Florida, but are ineffective for large scale control, very expensive, and cannot keep pace with the rapid plant growth in large water systems.

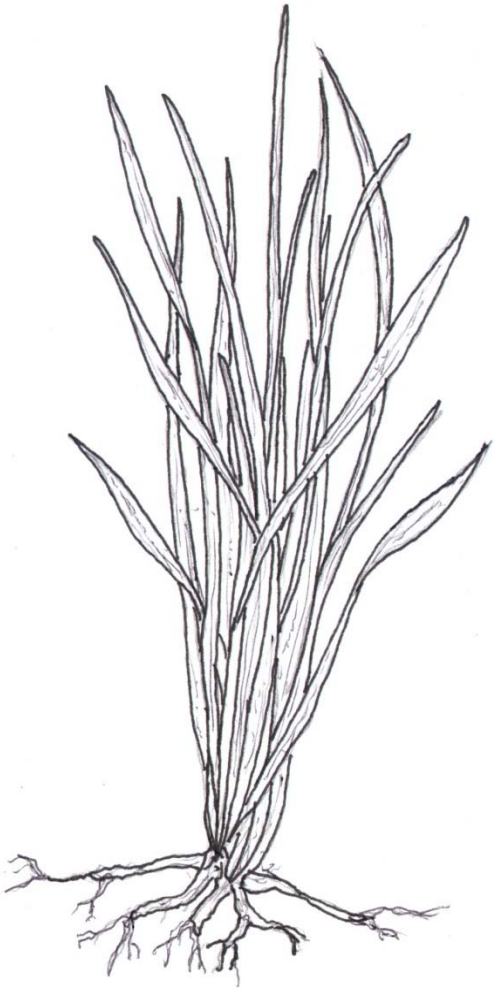
Biocontrol Potentials
Three insects have been released for the biological control of water hyacinth. These include two weevil species (*Neochetina* spp.) and a moth (*Sameodes albiguttalis*).

Unfortunately large scale reductions in water hyacinth populations did not occur. Instead insect predation reduced plant height, decreased the number of seeds produced, and decreased the seasonal growth of the plants. This, in turn, allowed better boat access into plant mats, reduced use of herbicides, and resulted in less plant problems.

In Louisiana, the seasonal growth of water hyacinth was reduced from a high of over 400,000 hectares per year to lows of only about 80,000 hectares.

This course contains EPA's federal rule requirements. Please be aware that each state implements pesticide regulations that may be more stringent than EPA's regulations and these frequently are changed. Check with your state environmental/pesticide agency for more information.

Cogongrass *Imperata cylindrica*



COGONGRASS

Cogongrass is an aggressive, rhizomatous, perennial grass that is distributed throughout the tropical and subtropical regions of the world. It has become established in the southeastern United States within the last fifty years, with Alabama, Mississippi, and Florida having extensive acreage of roadway and pasture infested with cogongrass. Cogongrass first appeared in the area around Grand Bay, Alabama as an escape from Satsuma orange crate packing in 1912. It was intentionally introduced from the Philippines into Mississippi as a possible forage in 1921. Cogongrass was introduced into Florida in the 1930s and 1940s as a potential forage and for soil stabilization purposes.

However, it was revealed that cogongrass was of little economic (forage) benefit and could become a serious pest. Consequently, it was placed on the noxious weed list, which prohibits new plantings. Unfortunately, cogongrass was spread by illegal plantings and inadvertent transport in forage and in soil during roadway construction. It does not survive in cultivated areas but becomes established along roadways, in forests, parks, and mining areas. It is now found throughout Florida from the panhandle region well into south Florida.

Coontail (*Ceratophyllum* Spp.)

The common name of this plant is very descriptive of its appearance (Figure 10). The leaves are 0.2 to 1.5 inches long in whorls on the stem, becoming more and more crowded near the tip.

Figure 10. Coontail.

Scientific Name	*Ceratophyllum demersum* L.
Common Name	Coontail
Family	Ceratophyllaceae (Coontail)
Class	Dicot
Description	Submersed free-floating (rootless) plant, highly branched, with whorled palmately dissected leaves, flowers inconspicuous, prolific seed former; evergreen perennial
US Distribution	All of North America
Worldwide Distribution	Almost global in distribution
Ecology	Submersed in 1 to 20 ft depth, wide range of water quality
Economic Importance	None
Ecological Importance	Important habitat for aquatic organisms, rarely produces a nuisance problem
Notes	Almost ubiquitous in standing water

Value - Coontail foliage is a favorite of many species of waterfowl. It is also home to many types of invertebrates, thus providing a great source of food for fish.

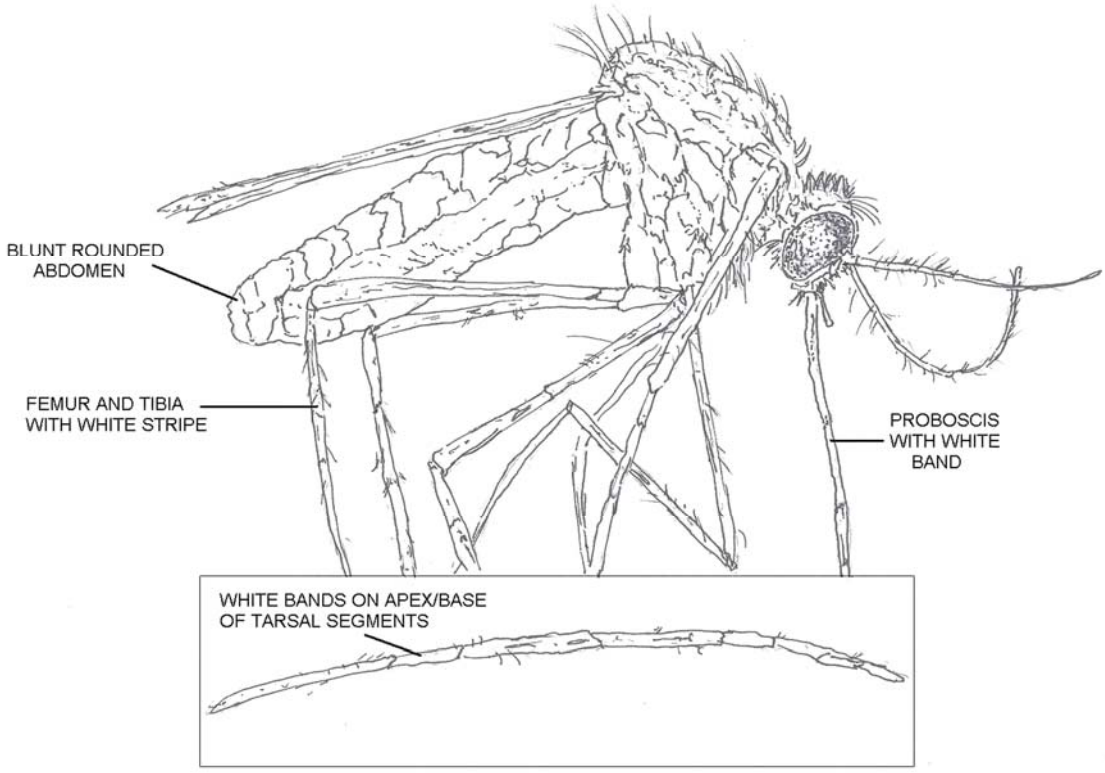
Nutrient Management - Overabundant plant growth is usually caused by excessive nutrients (nitrogen and phosphorous). These nutrients may come from runoff from barnyards, crop fields, septic systems, lawns, or golf courses.

Long-term control of overabundant plants is best accomplished by reducing or redirecting nutrient sources to the pond. This may be done by reducing fertilizer use near the pond, maintaining septic systems, directing nutrient-laden runoff away from the pond, or maintaining buffer strips around the pond. If you fail to address the underlying nutrient cause of plant growth, you must rely on continual removal of the plants using mechanical, biological or chemical control techniques.

Mechanical Control - Harvesting can be dangerous because this plant reproduces primarily from fragments. Attempts to harvest it may cause many fragments that may lead to new plants.

Biological Control-Grass Carp - Coontail may be controlled using grass carp.

Effective Herbicides - Aquathol-K, Hydrothol 191, Komeen, Reward, Sonar A.S. /Avast!, Sonar SRP/Avast! SRP



MOSQUITO (CULEX PIPENS)

Bladderwort (*Utricularia* Spp.)

Bladderworts are identifiable by small bladders produced randomly on the plant (Figure 11). Leaves have many fine thread-like segments. Although bladderworts are rootless plants, stems are sometimes attached to the bottom. Flowers of many species are yellow and grow above the water surface (Figure 12).

Figure 11. Bladderwort

Figure 12. Bladderwort flower.

The bladderworts received this name because of tiny bladder-like structures on their branched underwater leaves. (The wort part of the name comes from old English, when wort meant plant).These bladders are actually small vacuum traps which catch tiny aquatic animals.

The tiny traps are oval, with a membranous door at one end. Small trigger- hairs surround the door that secretes a sweet lure. When an animal comes near the hairs, the door snaps open in a fraction of a second, sucking the animal inside the bladder. Once trapped inside, the plant absorbs the animal's nutrients using digestive juices.

Due to their ability to 'eat' animals, bladderworts can live in nutrient poor, rather acidic, boggy conditions. However, they are also common in soft water lakes. Bladderworts are free-floating plants, but usually go unnoticed due to their habit of hanging out near the bottom in shallow areas. They usually attract attention in spring and summer when they float to the surface to send up shoots of small, attractive, yellow snapdragon like flowers.

The scientific name for the bladderworts is *Utricularia*. A few species are native, the two most common being *Utricularia vulgaris* or common bladderwort, and *Utricularia minor* or lesser bladderwort. When big floating bladderwort is flowering it is easily distinguished from its native cousins by large spoke-like floats that radiate out from the base of the flower stalk. During the rest of the year, however, it can be confused with common bladderwort, both of which are rather robust and can appear almost bushy underwater.

Chemical
The active ingredients that have been successful in treating bladderwort include 2,4-D (G), diquat (G), and fluridone (G). E = excellent, G = good

Navigate and **Aqua-Kleen** are 2,4-D compounds that have been effective on bladderwort. 2,4-D compounds are systemic herbicides.

Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides.

Reward is a liquid diquat formulation that has been effective on bladderwort. It is a contact algaecide and herbicide. Contact herbicides act quickly and kill all plants cells that they contact.

Sonar and **Avast** are fluridone compounds and come in both liquid and granular formulations and have been effective on bladderwort. These are broad spectrum, systemic herbicides. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides.

One danger with any chemical control method is the chance of an oxygen depletion after the treatment caused by the decomposition of the dead plant material.

Oxygen depletions can kill fish in the pond. If the pond is heavily infested with weeds it may be possible (depending on the herbicide chosen) to treat the pond in sections and let each section decompose for about two weeks before treating another section. Aeration, particularly at night, for several days after treatment may help control the oxygen depletion.

2017 Changes to EPA's Worker Protection Standard

In late 2015 the Environmental Protection Agency issued the long awaited revision to the Worker Protection Standard (WPS). This law it is now technically active and it will be enforced. Please keep in mind that the WPS covers both restricted use AND general use pesticides. This course is not for worker and/or handler training. Always follow the label and your State Pesticide Agency rules.

This course contains EPA's federal rule requirements. Please be aware that each state implements pesticide regulations that may be more stringent than EPA's regulations and these frequently are changed. Check with your state environmental/pesticide agency for more information.

Emersed (above water) Commonly Found Aquatic Weed Section

Plants in this group are rooted to the bottom but have several leaves or parts which extend above the water surface. Some of the plants in this group may grow in water 10 feet deep; most are shoreline or shallow water plants.

Waterlilies
Although not all the plants in this group are true waterlilies, they are often confused with waterlilies. This group of plants may also be called lily pad, cow lily, spatterdock and lotus. They are all rooted plants with floating leaves.

American Lotus (*Nelumbo lutea*)

American lotus leaves are large and circular, 8 to 25 inches in diameter (Figure 13). The center of the leaf is depressed, forming a cup. Leaves produced early in the season float on the water surface, and as the stem grows, the leaves become suspended above the water. The flower is pale-yellow and about 8 to 10 inches in diameter (Figure 14). Seeds are produced in a large distinctive fleshy receptacle which is yellow as the flower opens, then turns green and later, dark brown. Unlike other waterlilies, American lotus does not have a split or notched leaf.

Figure 13. American lotus.

Figure 14. American lotus flower.

Fragrant and White Waterlily (*Nymphaea* spp.*)*

Leaves of the true waterlilies are split or notched and are usually 6 to 8 inches in diameter. Fragrant waterlily (Figure 15), can be readily distinguished from white waterlily by its sweet-scented white or pink flowers. Flowers of white waterlily have little or no fragrance. Leaf veins of fragrant and white waterlilies originate from the leaf center and extend to the margin in a fan-like pattern (Figure 17).

Figure 15. Waterlily.

Figure 16. Spatterdock.

Figure 17. Waterlily leaf.

Fragrant white water lily

Flower: White, showy, fragrant, 7-20 cm wide; many petals; 4 green sepals; floats on water surface; open from mid-morning to early afternoon; throughout summer.
Leaves: Floating, 7-30 cm wide, rounded with narrow "V-shaped" split.
Other: Stalk is rounded with 4 air passages used to pump oxygen to roots.
Language of the Flower: Water lily means "coldness" or "purity of heart". The name of the water lily, *Nymphea*, is derived from the Greek word *nymphe*, meaning female deities associated with trees or water and represented as beautiful, young virgins. The virginity of the deities is the likely origin of the flower's association with coldness.

Water arum or wild calla; native perennial.

Family: Arum
Flower: Tiny; whitish or yellowish color; lack petals, in dense cluster on a fleshy spike above and hooded by a white oval bract; late May - early July.
Leaves: Basal leaves are heart-shaped, 5-10 cm long.
Fruit: Red, fleshy berries in dense heads. The fruit contains calcium oxalate crystals that are very poisonous.
Height: 10-30 cm.
Habitat: Wild calla grows near the water's edge of quiet ponds and lake margins.

Water Lettuce

Water lettuce

Scientific Name	*Pistia stratiotes* L.
Common Name	Waterlettuce
Family	Araceae (Arum)
Class	Monocot
Description	Floating rosette species, leaves with dense hairs, vegetatively reproduces by daughter plant formation; flowers inconspicuous
US Distribution	Coastal plain from Florida to Texas
Worldwide Distribution	Tropical and subtropical regions worldwide; native to Amazon basin, South America
Ecology	Floating mat to rooted in moist soil
Economic Importance	Major nuisance species in tropical and subtropical regions
Ecological Importance	Major negative impact to subtropical and tropical aquatic ecosystems
Notes	Less cold tolerant than water hyacinth, restricted to the warmest subtropical regions

The best way to track the spread of invasive aquatic plants may be to identify the drainage basins (watersheds) they have been discovered in. Drainage maps give useful information to resource managers because drainage maps show precisely where the plants are, making it easier for managers to infer where the plants might go next, and thus where to take preventive measures.

How it got here: *Pistia stratiotes*, water lettuce, is believed by some to be a native plant and by others to be a non-native plant that arrived in the ballast of explorer's sailing ships.

Pistia stratiotes continues to be sold through aquarium supply dealers; it is not on the U.S. Federal Noxious Weed List.

Potential to spread elsewhere in U.S.:

- water lettuce is found globally in the tropics and subtropics, but its spread is limited by severe cold (Holm *et al.* 1977); its leaves re-grow after moderate freezes.
- water lettuce reproduces vegetatively and sexually; new daughter plants are formed on stolons which grow from the mother plants; seedlings are produced in mild climates (Penfound & Earle 1948).

Problems/Effects:

- *Pistia stratiotes* mats clog waterways, making boating, fishing and almost all other water activities impossible.
- Water lettuce mats degrade water quality by blocking the air-water interface and greatly reducing oxygen levels in the water, eliminating underwater animals such as fish.
- Water lettuce mats greatly reduce biological diversity: mats eliminate native submersed plants by blocking sunlight, alter emersed plant communities by pushing away and crushing them, and also alter animal communities by blocking access to the water and/or eliminating plants the animals depend on for shelter and nesting.

Control

Decades of university, state, and federal research and experience with *Pistia stratiotes* in the U.S. has led to the development of several methods to help in its management: **mechanical harvesters and chopping machines** remove water lettuce from the water and transport it to disposal on shore; **chopping machines** grind the plant into bits and spray the slurry across the water. Years of research to find **insect biocontrols** has resulted in the successful introduction of two insects which are believed to be helpful in keeping water lettuce under maintenance control in many places; however, **biocontrol fish** which are able to control submersed plants are ineffective against the floating water lettuce.

Registered aquatic herbicides do provide temporary control of water lettuce.

From the University of Florida Aquatic Weed Management Guide by V.V. Vandiver, 1999:

According to this Guide, as always, comply with federal law by following the herbicide label instructions, permissible sites, and application rates.

What can you do?

First, clean your boat before you leave the ramp! Transporting plant fragments on boats, trailers, and in live wells is the main introduction route to new lakes and rivers.

Laws and lists:

Pistia stratiotes

- is "state-listed" in Arizona, Florida, Puerto Rico and South Carolina
- is on the Florida Prohibited Plants list, Florida Department of Environmental Protection:
- is on the Florida Exotic Pest Plant Council list:
  Category I - "plants invading and disrupting native plant communities in Florida"

Chemical

The active ingredients that have been successful in treating water lettuce include endothall (G), diquat (E), rodeo (G), and imazapyr (G). E = excellent, G = good

Aquathol, **Aquathol K**, and **Aquathol Super K** are dipotassium salts of endothall and comes in both liquid and granular formulations. The Aquathol K liquid formulation has been effective on water lettuce. Contact herbicides act quickly and kill all plant cells that they contact.

Reward is a liquid diquat formulation that has been effective on water lettuce. It is a contact algaecide and herbicide. Contact herbicides act quickly and kill all plants cells that they contact. A non-ionic aquatically registered surfactant (see the label) will have to be added to the Reward solution for good results.

Rodeo, **Aquamaster**, **Eraser AQ**, **Touchdown Pro**, and **AquaNeat** are liquid glyphosate formulations and have been effective on water lettuce. These are broad spectrum, systemic herbicides. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides. An aquatically registered surfactant (see the label) will have to be added to the glyphosate solution for good results.

Habitat contains the active ingredient, imazapyr, which inhibits the plant enzyme AHAS (acetohydroxyaced synthase). Habitat is a systemic herbicide that is effective on post-emergent floating and emergent aquatic vegetation. Imazapyr is effective at low-volume rates and does not contain heavy metals, organochlorides, or phosphates, making it safe to humans and livestock. Habitat requires the use of a spray adjuvant when applying on post-emergent vegetation.

One danger with any chemical control method is the chance of oxygen depletion after the treatment caused by the decomposition of the dead plant material. Oxygen depletions can kill fish in the pond. If the pond is heavily infested with weeds it may be possible (depending on the herbicide chosen) to treat the pond in sections and let each section decompose for about two weeks before treating another section. Aeration, particularly at night, for several days after treatment may help control the oxygen depletion.

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Spatterdock *(Nuphar luteum)*

Spatterdock is also known as pond lily, cow lily, and yellow waterlily (Figure 16). Leaves vary from nearly round to lance shaped and have a deep notch. The flower is yellow and shaped like a ball. Spatterdock can be distinguished from fragrant and white waterlily by the pattern of its leaf veins (Figures 17, 18). Spatterdock leaf veins originate from a main lateral vein and are not fan-like (Figure 18).

Figure 18. Spatterdock

Watershield (*Brasenia schreberi*)

Watershield; perennial, aquatic herb. Watershield may also be called dollar bonnet (Figure 19). The plants have floating, oval, or elliptical leaves 1 to 4 inches in size. Stems and the undersides of leaves are coated with a thick layer of gelatin-like material. This gelatinous material interferes with the uptake of some chemical treatments.

Figure 19. Watershield

Leaves: Oval and not split; 4-10 cm long; floating; underside is very slimy; stem is attached to the center of the leaf.
Stem: Submerged, slimy, attached to the center of the leaf.
Flowers: Dull purple-red color; 3-parted with 3 petals and 3 similar sepals; sits slightly above the water surface on stalks; June-August.
Habitat: Quiet, shallow lakes and ponds.

Floating-leaved Pondweed

Leaves: Leaf form can be quite variable; floating leaves are elliptical to oval in shape, stalked, leathery, with a waxy upper surface, many parallel veins, stalk joins at the base of each leaf; submerged leaves are bladeless, stalkless, 10-40 cm long, 1-2 mm wide, 3-5 veined.

Flowers: Small, 2-5 cm long spikes of flower clusters at stem tip; mid-summer.

Habitat: Shallow lakes and ponds, growing from organic-rich bottoms.

Similar plant: Floating-leaved pondweed is distinguished from Watershield by the junction of the stalk at the base of the leaf for floating-leaved pondweed vs. at the center of each floating leaf for water shield.

Water Pennywort (*Hydrocotyle umbellata*)

Water pennywort is usually found growing in water less than 2 inches deep (Figure 20). Dense stands may occasionally break loose and float in deeper water. Leaves are nearly round and are 0.5 to 1.2 inches in diameter.

Figure 20. Water pennywort.

Pickerelweed (*Pontederia codata*)

Pickerelweed usually grows in shallow water areas and is more common in the coastal areas of the Southeast (Figure 23). Leaves grow in clusters 2 to 6 inches wide and 4 to 12 inches long. The flowers are violet-blue in color.

Figure 23. Pickerelweed.

Flower: Violet; funnel-like, 5-10 mm long; on stalked spike; July-September.
Leaves: Single leaf from spreading rhizomes; parallel veins, lance- to egg-shaped, 5-25 cm long, 2-15 cm wide; long sheathing stalks. Height: 30-60 cm.

Habitat: Grows in water < 1 m deep. Interest: Pickerelweed forms dense colonies. Some people suggest that the name "Pickerelweed" reflects the habitat that this plant grows in is the same as the fish known as "pickerel".

Scientific Name	*Pontederia cordata* L.
Common Name	Pickerelweed
Family	Pontederiaceae (Pickerelweed)
Class	Monocot
Description	Stout emergent with heart-shaped leaves growing from a swollen base, perennial from base, showy purple flower spike forming numerous seeds
US Distribution	Eastern North America
Worldwide Distribution	Temperate North and South America
Ecology	Shallow emergent to moist soil habitats
Economic Importance	Prominent in revegetation efforts
Ecological Importance	Hardy emergent species, good habitat for young fish, macro invertebrates; seeds a secondary food source for wildlife
Notes	Considerable variation in leaf shape; this species is being micro propagated by tissue culture techniques as IFAS

Chemical
The active ingredients that have been successful in treating pickerelweed include 2,4-D (G), triclopyr (E), diquat (G), and imazapyr (E). E = excellent, G = good

Navigate and **Aqua-Kleen** are 2,4-D compounds that have been effective on pickerelweed. 2,4-D compounds are systemic herbicides. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides.

Renovate is a liquid triclopyr formulation that is effective on pickerelweed. It is a selective broadleaf, systemic herbicide. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides. An aquatically registered surfactant (see the label) will improve the effectiveness of triclopyr.

Reward is a liquid diquat formulation that has been effective on pickerelweed. It is a contact herbicide. Contact herbicides act quickly and kill all plants cells that they contact. A non-ionic aquatically registered surfactant (see the label) will have to be added to the Reward solution for good results.

Habitat contains the active ingredient imazapyr, which inhibits the plant enzyme AHAS (acetohydroxyaced synthase). Habitat is a systemic herbicide that is effective on post-emergent floating and emergent aquatic vegetation. Imazapyr is effective at low-volume rates and does not contain heavy metals, organochlorides, or phosphates.

Frogbit (*Limnobium spongia*)

Frogbit has two leaf forms. The floating or underwater leaves are heart shaped and have a deep notch (Figure 21). The underside of the leaf is thick in the center and spongy (Figure 22). The out-of-water leaves are also heart-shaped, but not as thick in the center or deeply notched, and they have a leathery feel. Frogbit may be found either growing rooted to the bottom mud in shallow water or floating on the water surface. It usually grows three inches or less in height.

Figure 21. Frogbit.

Figure 22. Frogbit--underside of floating leaf.

Chemical
The active ingredients that have been successful in treating frog's-bit include 2,4-D (E), diquat (E), imazapyr (E). E = excellent, G = good

Navigate and **Aqua-Kleen** are 2,4-D compounds that have been very effective on frog's-bit. 2,4-D compounds are systemic herbicides. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides.

Reward is a liquid diquat formulation that has been very effective on frog's-bit. It is a contact herbicide. Contact herbicides act quickly and kill all plants cells that they contact. A non-ionic aquatically registered surfactant (see the label) will have to be added to the Reward solution for good results.

Habitat contains the active ingredient, imazapyr, which inhibits the plant enzyme AHAS (acetohydroxyaced synthase). Habitat is a systemic herbicide that is effective on post-emergent floating and emergent aquatic vegetation. Imazapyr is effective at low-volume rates and does not contain heavy metals, organochlorides or phosphates, making it safe to humans and livestock. Habitat requires the use of a spray adjuvant when applying on post-emergent vegetation.

One danger with any chemical control method is the chance of an oxygen depletion after the treatment caused by the decomposition of the dead plant material.

Oxygen depletions can kill fish in the pond. If the pond is heavily infested with weeds it may be possible (depending on the herbicide chosen) to treat the pond in sections and let each section decompose for about two weeks before treating another section. Aeration, particularly at night, for several days after treatment may help control the oxygen depletion.

Alligatorweed (*Alternanthera philoxeroides*)

Alligator weed grows in a wide range of soil and water conditions (Figure 24). Growing plants usually form an interwoven mat which may be free floating, rooted and above water, or in a dry field. It is more common in the coastal areas. Leaves are 2 to 5 inches long, lance shaped, and have a distinct mid-rib. Flowers are white.

Figure 24. Alligatorweed.

Scientific Name:	*Alternanthera philoxeroides* (Mart.) Griseb
Common Name:	Alligatorweed
Family:	Amaranthaceae (Amaranth)
Class:	Dicot
Description:	Emersed or submersed perennial, leaves opposite and simple, flowering head of small white flowers borne in axils.
US Distribution:	Coastal states from Virginia to Texas
Worldwide Distribution:	Native to South America
Ecology:	Rooted in shallow submersed habitats to moist soil sites; may form floating mats
Economic Importance:	Major nuisance to subtropical aquatic sites and wetland areas, especially ditch and stream habitats
Ecological Importance:	Major impact on aquatic and wetland sites
Notes:	Some evidence exists for two biotypes with different responses to biocontrol and chemical controls; aquatic form has a hollow stem.

Introduction: Alligatorweed is a perennial aquatic weed commonly found in shallow waterways in the Southern States. It belongs to the pigweed family and is sometimes accidentally introduced to landscape situations with new St. Augustine sod. It can survive on terrestrial sites that remain wet or boggy.

Description: Alligatorweed has 2 to 5 inch oppositely arranged leaves that are elliptic shaped and have a distinct mid-rib. This species has white flowers. Leaves have hollow and very smooth stems. It can go unrecognized in closely mowed St. Augustine turf.

Control: The best control is to inspect sod to make sure the weed is not present. If the weed is present in large enough quantities it can compete for water and nutrients and cause sparse areas in the new turf. Under normal circumstances the weed should die out in 4-8 weeks because soil and moisture conditions in Coastal Georgia are not favorable to alligatorweed. There are no herbicides labeled for alligatorweed control in turfgrass. However, if the problem persists for more than 2 months and the turf is well established, Image can be sprayed at maximum rates. Image has good activity on pigweeds, and as alligatorweed is in the pigweed family, Image may very well control this weed. Alternatively, two-way and three-way herbicides that contain 2,4-D and dicamba may also be used. But, these products can severely injure St. Augustine grass, and should only be used at the lowest rate recommended on the label for St. Augustine grass and centipedegrass.

Chemical
The active ingredients that have been successful in treating alligatorweed include 2,4-D (G), glyphosate (G), triclopyr (E), fluridone (G), and imazapyr (E). E = excellent, G = good

Navigate and **Aqua-Kleen** are 2,4-D compounds that have been effective on alligator weed. 2,4-D compounds are systemic herbicides. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides.
Rodeo, **Aquamaster**, **Eraser AQ**, **Touchdown Pro**, and **AquaNeat** are liquid glyphosate formulations and have been effective on alligatorweed above the water line but ineffective on plants in the water. They are broad spectrum, systemic herbicides. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides. An aquatically registered surfactant (see the label) will have to be added to the glyphosate solution for good results.
Renovate is a liquid triclopyr formulation that is effective on alligatorweed. It is a selective broadleaf, systemic herbicide. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides. An aquatically registered surfactant (see the label) will improve the effectiveness of triclopyr.
Sonar and **Avast** are fluridone compounds, come in both liquid and granular formulations, and have been effective on alligatorweed in the water. These are broad spectrum, systemic herbicides. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides.
Habitat contains the active ingredient, imazapyr, which inhibits the plant enzyme AHAS (acetohydroxyaced synthase). Habitat is a systemic herbicide that is effective on post-emergent floating and emergent aquatic vegetation. Imazapyr is effective at low-volume rates and does not contain heavy metals, organochlorides or phosphates, making it safe to humans and livestock. Habitat requires the use of a spray adjuvant when applying on post-emergent vegetation.

Smartweed (*Polygonum* spp.)

Smartweed is a shallow water plant (Figure 25). Each joint or node is covered by a thin white to brown sheath. Leaves are linear or elliptic and alternate. Flowers are white, pink, pinkish-white or green.

Figure 25. Smartweed.

Flower: Tiny, pink flowers; 4 mm long; slender, spike-like clusters 4-17 cm long; 5 parted calyx, lacks petals; July-September.
Leaves: Lanceolate, tapering at both ends; 5-20 cm long; may be floating; may encircle the stem where leaf joins stem.
Height: 60-90 cm.

Biological
There is no known biological control for smartweed, although goats are known to forage on many types of emergent vegetation.

Chemical
The active ingredients that have been successful in treating smartweed include 2,4-D (E), triclopyr (G), and glyphosate (E). E = excellent, G = good
Navigate and **Aqua-Kleen** are 2,4-D compounds that have been effective on smartweed. 2,4-D compounds are systemic herbicides. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides.
Renovate is a liquid triclopyr formulation that is effective on smartweed. It is a selective broadleaf, systemic herbicide. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides. An aquatically registered surfactant (see the label) will improve the effectiveness of triclopyr.
Rodeo, **Aquamaster**, **Eraser AQ**, **Touchdown Pro**, and **AquaNeat** are liquid glyphosate formulations and have been effective on smartweed. These are broad spectrum, systemic herbicides. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides. An aquatically registered surfactant (see the label) will have to be added to the glyphosate solution for good results.
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before treating another section. Aeration, particularly at night, for several days after treatment may help control the oxygen depletion.

Pink Smartweed (*Polygonum bicorne* Raf.)

Erect, climbing plant, up to 2 meters tall, with clusters of small pink flowers on a slender spike. Member of the Buckwheat Family (Polygonaceae) along with Knotweed and Buckwheat. Seen here growing in shallow water with water willow; Lake Kahola, east-central Kansas. Based on Freeman and Schofield (1991) and Zim and Martin (1950).

Arrowhead (*Sagittaria* Spp.)

Arrowhead is a shallow water plant (Figure 26). Leaf shapes are highly variable; however, they are usually in the shape of an "arrowhead". Leaves are usually above the water, but they may be under the water or floating.

Figure 26. Arrowhead.

Water Primrose (*Jussiaea* Spp.--*Ludwigia* Spp.)

Water primrose grows along the shoreline and in shallow water areas (Figure 27). Leaves are light green, about 3 inches long, and lance-or-oval shaped. Stems may appear reddish-green. Flowers are bright yellow, about one inch in diameter and have 5 petals.

Figure 27. Water primrose.

Biological
There is no known biological control for water primrose, although goats are known to forage on many types of emergent vegetation.

Chemical
The active ingredients that have been successful in treating water primrose include 2,4-D (E), diquat (E), triclopyr (E), glyphosate (E), and imazapyr (E). E = excellent, G = good

Navigate and **Aqua-Kleen** are 2,4-D compounds that have been effective on water primrose. 2,4-D compounds are systemic herbicides. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides.

Reward is a liquid diquat formulation that has been effective on water primrose. It is a contact herbicide. Contact herbicides act quickly and kill all plant cells that they contact. A non-ionic aquatically registered surfactant (see the label) will have to be added to the Reward solution for good results.

Renovate is a liquid triclopyr formulation that is effective on water primrose. It is a selective broadleaf, systemic herbicide. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides. An aquatically registered surfactant (see the label) will improve the effectiveness of triclopyr.

Rodeo, **Aquamaster**, **Eraser AQ**, **Touchdown Pro**, and **AquaNeat**are liquid glyphosate formulations and have been effective on water primrose. These are broad spectrum, systemic herbicides. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides. An aquatically registered surfactant (see the label) will have to be added to the glyphosate solution for good results.

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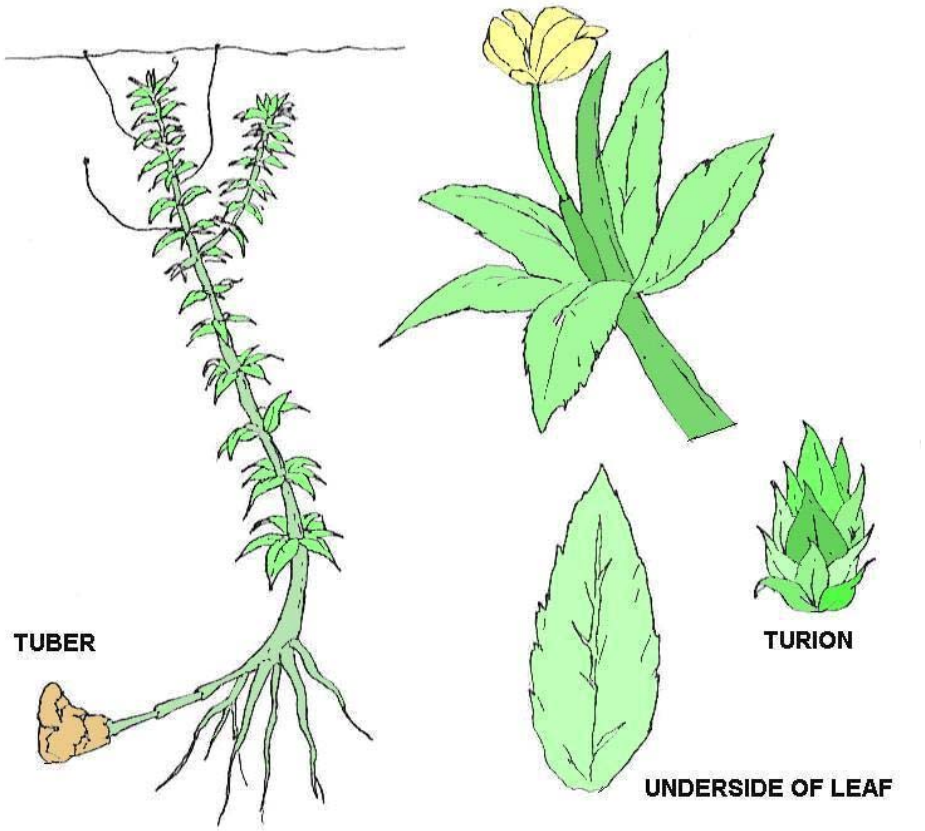


HYDRILLA (Hydrilla vertcillata)

Cattails (*Typha* Spp.)

Cattails usually grow along the shoreline and are sometimes found in water 3 to 4 feet deep (Figure 28). Plants may attain a height of 6 to 8 feet. Leaves are about 1 inch wide, and ribbon shaped flowers are produced on the end of stalks in cylindrical clusters; hence the name "cattail."

Figure 28. Cattail.

Scientific Name	*Typha* spp. L. (*T. latifolia, T. glauca, T. angustifolia, T. domingensis*)
Common Name	Cattail
Family	Typhaceae (Cattail)
Class	Monocot
Description	Primarily emergent from subterranean rhizome, leaves long and strap-like flowers inconspicuous in floral head, with sexes separate, wind pollinated
US Distribution	Throughout US and southern Canada
Worldwide Distribution	Temperate North America, Europe, and Asia
Ecology	Emergent in up to 3 ft. depth, to moist soil
Economic Importance	May become a nuisance, also as a roost for blackbird swarms
Ecological Importance	Can be good cover for wildlife, food for muskrats, etc.; may out-compete other natives in some situations (prairie pothole region)

Notes	Some of these species hybridize; some evidence that *T. latifolia* is not native

Cattails

The common cattail is a native, opportunistic North American wetland species. The narrow-leaved cattail is possibly an exotic or hybrid. Cattails can be found in damp soil or shallow water where sufficient nutrients are available. It is a common site along expressways, in artificial ditches and shallow ponds, at the edges of calm waters, in consistently damp patches of rural and suburban yards, and in freshwater marshes. This prolific plant plays an important role as a source of food and shelter for different marsh-dwelling animals, especially when cattails form large stands on relatively open, wet soils abutted by water.

The velvety brown flower head and long, graceful lanceolate leaves of the cattail are a common site throughout wetlands. The flower head, shaped like an elongate cylinder, is a compact spike at the terminal end of a stem 1-3 meters tall.

The flower spike is divided into two readily distinguishable parts: pistillate flowers form the conspicuous brown club located below the yellow spire of staminate flowers. The leaves originate at the base of the stem and spread outward as they rise into the air. Below ground, starchy rhizomes anchor the plant to the soil. If the plants are growing in a colony, their rhizomes may become intertwined and form a dense mat.

Of the two commonly found species of cattail that exist, common cattail is taller and generally more robust than the narrow-leaved variety. Observation of the flower spike also helps distinguish the two species.

The pistillate and staminate flowers of the common cattail emerge in direct contact with one another, with no gap separating the male and female flower parts; on the flower spike of the narrow-leaved cattail, the pistillate and staminate flowers are separated by a gap 2-10 centimeters in length.

Cattails reproduce sexually by seed and vegetatively by the production of rhizomes. The flower head of the parent plant can produce 250,000 seeds, which are then wind-dispersed. Seeds remain viable in the seed bank for up to 100 years. Cattail seeds prefer freshwater, and will not germinate unless saturated in at least 0.5-1 inch of water. Sunlight affects germination rates; seeds will remain quiescent if the area does not receive the proper amount of sunlight.

Cattails also reproduce asexually by rhizomes. During the first summer of vegetative propagation, rhizomes grow about two feet in length. New shoots emerge at the rhizome around mid-summer. Cattails can quickly dominate a wetland plant community and produce monotypic stands that reduce the overall habitat value.

Control Methods
The acreage of cattail-dominated wetlands in the United States has increased drastically since the early twentieth century due to changes in hydrology and land use. The optimal control technique for a given site will depend on the hydrologic state of the site, the size of the area to be managed, and whether the manager is able to manipulate water levels.


Narrow-leaved Cattails

Mechanical Control:
Water Level: The control of cattails by the manipulation of water level must be timed to the annual cycle of carbohydrate storage. Special leaf and stem cells called aerenchyma provide air passage from both living and dead leaves to the rhizomes. Removing dead leaves and submerging the shoots in early spring will strain the plant and eventually kill it. The depth of water necessary to kill the plants depends on temperature; the quantity of starch the plant stored the previous year, and the general vigor of the plants. Therefore, no minimum water depth can be prescribed, but generally, a water level maintained at 3-4 feet above the tops of existing spring shoots will retard growth.

It is critical to remember that even if dead leaves from the previous year are completely removed, aerobic conditions will be restored to the rhizome as soon as the new growing shoot penetrates the water surface.

Even if water levels are sustained at only a few inches above the tops of the growing shoots, oxygen is prevented from reaching the rhizomes. The use of water is most efficient if the water level is raised progressively, so that all plant parts remain submerged by no more than a few inches. Water levels in the range of four to five feet also favor the wintertime survival of muskrats in flooded areas. Population levels of ten muskrats per acre, when combined with high springtime water levels, can nearly eliminate the emergence of cattails within a span of two years.

Cutting, Crushing, Shearing, and Discing
Starch reserves in the rhizomes are at their minimum in late spring when the pistillate spike of the cattail is lime green and the staminate spike is dark green. This is the best time to employ cutting, crushing, shearing, and/or disking to eliminate cattail colonies, because all these methods impede starch storage during the growing season. The methods of control work best if employed during a three-week time window beginning one week before and ending one week after the staminate spike has emerged.

Deep discing can retard shoot formation and damage the rhizomes, but should be used in combination with water-level control and the prevention of seed establishment to effectively hinder the re-emergence of cattails. Discing combined with continued drying and freezing in fall decreases plant survival; if a wetland can be kept dry enough to repetitively disk for 2-3 successive seasons, cattails can be eliminated or their stem densities severely reduced. However, disking has some major drawbacks: the equipment and personnel needed to carry out this method of control are costly, and will seriously disturb the site. This will likely result in the loss of other native plants in the area as well.

Cutting, crushing, shearing, or disking severs the aerenchyma link that provides oxygen between the rhizomes and leaves of cattails during dormancy. These techniques must be combined with high springtime water levels in order to effectively retard plant growth.

Cattails can be cut with a rotary mower or sheared with a front-end loader on a tractor when equipment can be driven on ice, but airborne seeds may clog equipment. High water levels must be maintained throughout the spring and early summer.

Bulldozer
Bulldozers can effectively remove plants from a marsh, but will generally drastically disturb the wetland. Permits must be obtained before clearing a marsh with heavy equipment. A bulldozer or other machinery is the only viable method that will remove floating cattail mats, but these removal methods are also costly, and effects may be short-lived. If the seed bank of the marsh is dominated by cattails, a new colony of the hardy plants may spring up after the next drawdown of the marsh; other undesirable plants could also take the place of the cattails in the marsh.

Grazing
Grazing by cows, geese, muskrats, and other animals can be an effective method of cattail management. Grazing on seedlings and young cattails without extensive rhizomes can reduce the stem density of the colony. For mature plants, grazing combined with water-level management reduces survival rates. To maximize the impact of grazing, it should be heaviest during the three-week window of time when the flower spikes are emerging.

Prescribed Burning
Most cattail marshes must be burned in winter or before significant growth has occurred in spring; these are generally the only times when fuels are dry enough to carry a fire, although frozen ground or saturated soil may impede the fire's progress through the cattail duff. Fire is most effective as a control method when followed by naturally or artificially high water levels in the spring to smother residual stalks.

Drought
During times of drought, cattail stands overlying well-developed peat soils can be eliminated by burning. Because such fires burn peat, the ability to smother the fire by re-flooding the marsh must exist before a prescribed burn can be implemented. Peat fires can also cause undesirable changes in the marsh environment, such as destruction of the seed bank, loss of peat, and air pollution.

Chemical Control
Application in mid to late summer enhances the effectiveness of translocated herbicides, although the herbicides will have little effect on seed production during the year of application. A hemi-marsh may be created if some cattails survive, although the ability of the marsh to persist in this condition depends on the manipulation of water levels. Water level control to minimize recruitment from the seed bank must be used to ensure cattails will not return once reduced by herbicides.

Herbicides can be detrimental to wetlands habitats--be sure to use herbicides that readily break down in water, soil, or substrate, such as glyphosate formulated for use over water. Boom or wick applications by ground or air boat are best for small areas where pesticide drift is a concern. Aerial applications may be used on large areas. Herbicidal control of cattails may be costly, although actual application of the herbicide usually represents a small fraction of this cost.

One area manager found that an aerial application of glyphosate during August was effective in controlling cattails, dogwood, and willow, but quite costly at $110/acre. Due to the possibility of fish contamination, notice must be posted before spraying, and can be done only by a person licensed to apply herbicides.

The active ingredients that have been successful in treating cattails include diquat (G), glyphosate (E), and imazapyr (E). n E = excellent, G = good

Reward is a liquid diquat formulation that has been effective on cattails. It is a contact herbicide. Contact herbicides act quickly and kill all plant cells that they contact. A non-ionic aquatically registered surfactant (see the label) will have to be added to the Reward solution for good results.

Rodeo, **Aquamaster**, **Eraser AQ**, **Touchdown Pro**, and **AquaNeat** are liquid glyphosate formulations and have been effective on cattails. These are broad spectrum, systemic herbicides. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides. An aquatically registered surfactant (see the label) will have to be added to the glyphosate solution for good results.

Habitat contains the active ingredient, imazapyr, which inhibits the plant enzyme AHAS (acetohydroxyaced synthase). Habitat is a systemic herbicide that is effective on post-emergent floating and emergent aquatic vegetation. Imazapyr is effective at low-volume rates and does not contain heavy metals, organochlorides or phosphates, making it safe to humans and livestock. Habitat requires the use of a spray adjuvant when applying on post-emergent vegetation.

One danger with any chemical control method is the chance of an oxygen depletion after the treatment, caused by the decomposition of the dead plant material. Oxygen depletions can kill fish in the pond. If the pond is heavily infested with weeds it may be possible (depending on the herbicide chosen) to treat the pond in sections and let each section decompose for about two weeks before treating another section. Aeration, particularly at night, for several days after treatment may help control the oxygen depletion.

Control of Cattails and Duckweed in Wastewater Lagoons

A properly functioning lagoon should be maintained on a regular basis. This includes keeping the berms free of trees and weeds and ensuring that no animals are burrowing in the berms. The water of the lagoon should be a green color, due to the algae present, and be reasonably free of cattails.

The lagoon should have little to no odor. Cattail and duckweed are two weeds that tend to multiply rapidly, thrive in the sewage environment, and take over the entire lagoon if allowed.

A few duckweeds will not hurt a lagoon, but if the duckweeds become so dense that they block out the sunlight, they can be detrimental to the healthy balance that the lagoon needs to function properly. The dense cover will reduce the light, killing the algae, thus reducing the oxygen level in the lagoon.

This may cause an odor problem so the duckweed needs to be controlled. These weeds may be controlled by chemical or physical means.

Chemicals work best, but either method may be short lived as one duckweed can reproduce to cover 10 square feet in one day.

Purple Loosestrife

Purple Loosestrife

Scientific Name	*Lythrum salicaria* L.
Common Name	Purple Loosestrife
Family	Lythraceae (Loosestrife)
Class	Dicot
Description	Erect herbaceous perennial, overwinters by root crown, showy purple flowers, prolific seed production
US Distribution	Northern two-thirds of US and southern Canada
Worldwide Distribution	Temperate northern hemisphere and Australia; not a nuisance in Europe; native to Europe
Ecology	Moist soil to emergent shallow water areas, may even grow in moist upland areas
Economic Importance	Imported for honey production and as an ornamental
Ecological Importance	Major negative impact on wetlands in North America; reduces waterfowl food and nesting
Notes	Seedlings established best on moist soil or mudflats

What is it?
Purple Loosestrife (*Lythrum salicaria*) is a perennial wetland herb that grows in sunny wetlands, ditches, around farm ponds and in other disturbed habitat. It is native to Europe and was accidentally introduced into North America in the mid-1800s. Because it has no natural enemies here, it has spread aggressively into wetlands throughout the northeast and the upper Midwest. In fact, it is known to have occurred in over 40 of 48 contiguous states

Purple Loosestrife has showy purple spikes of flowers, making it an attractive garden flower. The use of purple loosestrife in landscape plantings and flower gardens has added to its spread in the United States. Seven hybrids that are considered non-aggressive are now commercially available. They are: Morden Pink, The Rocket, Rose Queen, Dropmore Purple, Columbia Pink, Morden Rose and Morden Gleam.

Why Is It A Problem?
Purple Loosestrife reproduces prolifically by cuttings and offshoots as well as by seeds. A single plant may produce up to 300,000 seeds, which are carried by wind, water and animals. Purple Loosestrife is so aggressive that it crowds out the native plants that are used by wildlife for food and shelter. Purple Loosestrife has almost no wildlife food and shelter value, and so where it invades, valuable wildlife habitat is destroyed. Once established it can destroy marshes and wet prairies and choke waterways.

Where and When to Look
It formerly occurred primarily in the northeast quarter of the country, but now might be found anywhere. The brilliant purple spikes are showy from late June or early July through late August. Look for it in marshes, wet prairies, along streams, around farm ponds, and in moist fields, pastures and roadside ditches.

How to Control It
Purple Loosestrife spreads rapidly by the very numerous seeds (up to 300,000 per plant) produced annually. For this reason it is very important to locate and eradicate the first plants to invade a wetland basin or habitat. An ounce of prevention is worth many, many pounds of cure later on.

Small infestations of up to 100 plants are best eliminated by hand pulling. Pull all or as much as possible of the root system out. If the plants are simply broken off at the soil surface, the "root crown" will sprout new stems. Pull plants early in the flowering season if possible to avoid scattering seeds in the removal process.

Remove all stems from the wetland area, as discarded stems will sprout and create new plants. Clusters in excess of 100 plants, up to three acres, and plants too large to pull out, are best controlled by herbicides. Currently, Loosestrife can be controlled with Roundup on terrestrial sites and Rodeo in wetlands and over water. These are U.S. Environmental Protection Agency registered herbicides that should be applied by licensed herbicide applicators following label instructions.

Larger infestations are not presently controllable but may be contained in some situations by pulling and/or herbicide treatment of individual plants as they spread around the periphery of dense stands. Effective control of large infestations is dependent on future research. Present action is aimed at containing the spread of this weed.

Sedges and Rushes Section

There are many species of rushes and sedges in the U.S. Few of them are ever a problem in pond management. Examples of some members of this family are illustrated (Figure 29).

Figure 29. Rushes.

One species, slender spikerush (Eleocharis acicularis), is a major problem in some ponds (Figure 30). Slender spikerush plants are small and hair-like varying from 2 to 6 inches long. Leaves arise from the base of the plant in tufts. Plants grow along the bottom, but may break away and form living floating mats.

Figure 30. Slender spikerush.

Spike Rushes (*Eleocharis spp.*)

Grass-like plants that grow in clumps from 10 cm to 1½ m tall, depending on species. Characterized by leafless stems, each of which has a small fruiting spike at the top. Spike rushes are quite common in and diagnostic of wetland environments in temperate regions around the world. They provide shelter for fish, amphibians, and insects, and are a food resource for many wetland birds and mammals. Pictured here is the **Blunt Spike Rush** (*Eleocharis obtusa*) growing in a shallow stream channel.

Water Willow (*Justicia americana*)

Erect stems with opposed, willow-shaped leaves, for which the plant is named. Small, orchid-like, white flowers bloom on long-stemmed spikes. Roots are usually submerged in shallow water along stream or pond margins. Greatest value of water willow is for stabilizing streambeds and shorelines.

Bulrushes (*Scirpus spp.*)

Bulrushes, among the most beneficial emergent wetland plants, are actually members of the sedge family. They are found in all types of fresh and alkali wetland settings--marshes, river banks, and lake shorelines. They may form dense thickets along the margins of water bodies. The seeds are particularly valuable for ducks; bulrush provides nesting habitat, and it binds wet soils quite effectively. Also known as tule or club rush. **Great Bulrush** (*Scirpus validus*).

Mechanical/Physical

Bulrushes can be cut and the rhizomes can be dug up but physical control is difficult because it can reestablish from seeds and remaining rhizomes. Frequent mowing has been somewhat effective in the control of bulrush. There is no known biological control for bulrush, although goats are known to forage on many types of emergent vegetation.

Chemical

The active ingredient that has been most successful in treating bull rushes is glyphosate.

Rodeo, **Aquamaster**, **Eraser AQ**, **Touchdown Pro**, and **AquaNeat** are liquid glyphosate formulations and have been effective on bulrushes. They are a broad spectrum, systemic herbicide. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides. An aquatically registered surfactant (see the label) will have to be added to the glyphosate solution for good results.

Aquatic Woody Plant Section

There are a large number of woody plants that may grow along the edges of a pond which are potential problems to pond management. There are 4 species in the U.S. that are a common problem; buttonbush (Cephalanthus occidentalis), willows (Salix spp.), salt cedar (Tamarix spp.) and alders (Alnus spp.).

Buttonbush

Buttonbush is a small to medium sized shrub (Figure 31). The flowering heads of this shrub resemble buttons at a distance. Leaves are whorled, 2 to 6 inches long, elliptic or oval shaped, and coarse textured.

Figure 31. Buttonbush.

Willows

Willows are large shrubs or trees with alternate leaves which are several times longer than wide (Figure 32). The leaves are usually toothed on the margin. The wood is soft and light, and the bark is aromatic but has a bitter taste.

Figure 32. Willow.

Alders

Alders are large shrubs or small trees whose alternate leaves are coarse textured, heavy veined, and toothed (Figure 33). Flowers occur in clusters and resemble small pine cones when mature.

Figure 33. Alder.

The best-known species in Europe is the Common or Black Alder (A. glutinosa), native to most of Europe and widely introduced elsewhere. The largest species is Red Alder (A. rubra), reaching 35 m (the tallest is 32 m) on the west coast of North America, with Black Alder and Italian Alder (A. cordata) both reaching about 30 m. By contrast, the widespread Green Alder (A. viridis) is rarely more than a 5 m shrub.

Alders establish symbioses with the nitrogen-fixing Actinobacteria Frankiella alni. This bacteria converts atmospheric nitrogen into soil-soluble nitrates which can be utilized by the alder, and favorably enhances the soil fertility generally. Alders benefit other plants growing near them by taking nitrogen out of the air and depositing it in the soil in usable form; fallen alder leaves make very rich compost.

Alders are sturdy and fast-growing, even in acidic and damaged sites such as burned areas and mining sites. Italian Alder is particularly useful on dry, infertile sites. Alders can be used as a producer of simple bio-mass, growing quickly in harsh environments.

Alder catkins are one of the first sources of pollen for bee species, especially honeybees, which use it for spring buildup. Alders are also used as a food plant by some Lepidoptera (butterfly and moth) species, see list of Lepidoptera that feed on alders. Alders are also grown in gardens, and are sometimes made into bonsai.

Alder is a preferred wood for charcoal making, formerly used in the manufacture of gunpowder, or for smelting metal ores, now used primarily for cooking. The wood is also traditionally used for smoking fish and meat, though this usage has often been replaced by other woods such as oak and hickory.

Tamarisk Saltcedar (*Tamarix spp)*

Saltcedar

This term includes *Tamarix* spp., especially *T. ramosissima* (Ledeb.), which is generally (but incorrectly) known as *T. pentandra* (Baum 1978). Saltcedar is a native of Eurasia and Africa, was introduced into the United States as an ornamental shrub in the early 1800s, and has now spread throughout the inter-mountain region of the western United States (Carman and Brotherson 1982). Saltcedar is considered beneficial in that it provides good nesting habitat for wildlife (including doves) and is an excellent source of nectar for honeybees in Arizona and New Mexico (Deloach 1989).

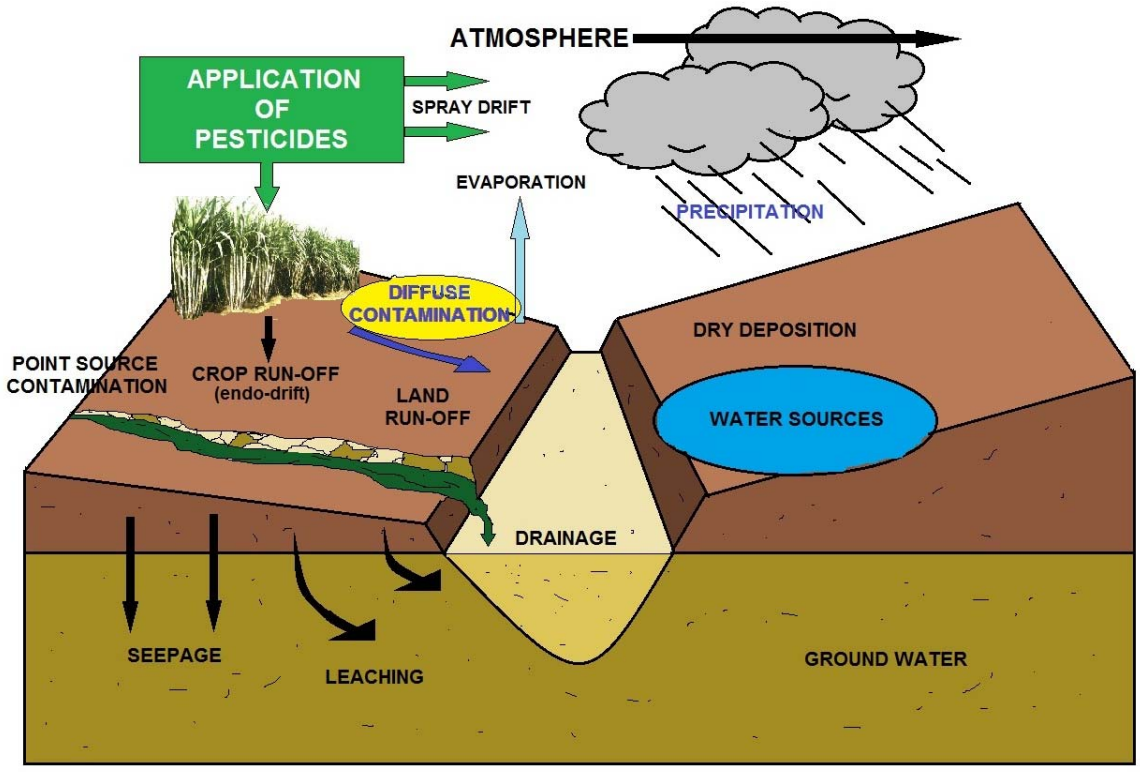
Saltcedar is a deciduous shrub or small tree growing to 12'-15' in height. Slender, long gray-green branches are spreading or upright, often forming dense thickets. Scalelike leaves are gray-green, alternately arranged, narrow, pointed, about 1/16" long, and overlap one another on the stems. Active growth occurs from early or mid-spring to fall, when leaves drop. Leaves often become encrusted with salt secretions. Branches take on a brown-purple color as they age. Bark is reddish-brown and smooth on young branches, becoming ridged and furrowed on older limbs. Large numbers of pink to white flowers, about 1/16" across, appear in a dense mass on 1/2"- 2" spikes at branch tips from March to September. Flowers are pollinated by bees and other insects and produce greenish-yellow to pinkish-red capsules, 1/8"-1/5" long, which split into three to five parts on maturity. Seeds are 1/25" long, with a tuft of fine hairs at one end. The number of seeds per capsule is not constant. Seeds are dispersed by wind to new locations. Seedlings require extended

periods of soil saturation for establishment. Large bush or small coniferous tree, up to 4 meters tall, with attractive pink flowers.

Saltcedar originated in Eurasia and Africa and was brought to North America as an ornamental shrub. During the 1930s, it was planted widely in the Great Plains and American West in windbreaks to control soil erosion. Since then, saltcedar has become an invasive plant that grows in dense thickets along streams, rivers and wetlands. It has displaced native vegetation, changed wildlife habitat, and increased fire risk.

Saltcedar occurs in moist rangeland and pastures, bottomlands, banks, and drainage washes of natural or artificial waterbodies, and in other areas where seedlings can be exposed to extended periods of saturated soil conditions for establishment. Saltcedar can grow on soils with up to 15,000 ppm soluble salt. Established plants have long roots that can tap deep water tables. Furthermore, saltcedar has the highest known evapotranspiration rate of any desert phreatophyte (Carman and Brotherson 1982), which may result in water depletion from the underlying soil.

Among the serious direct impacts of this species are the displacement of native range plants by its aggressive growth, the possibly serious depletion of ground water due to its rapid evapotranspiration rate, increased deposition of sediments in tamarisk- infested streams, and the blockage of streams and artificial water channels by dense clumps of saltcedar growth, which can promote flooding during periods of heavy rain.



ENVIRONMENTAL CONTAMINATION FROM PESTICIDES

Grasses

There are many grass species that can be a management problem in ponds. Maidencane (Panicum hemitomon) and southern watergrass (Hydrochloa caroliniensis) are probably the most common and difficult to control.

Maidencane

The stalks are long and narrow (Figure 34). Stems may be 3 to 8 feet tall growing in up to 2 feet of water. Leaf blades are 4 to 10 inches long and 0.2 to 0.6 inches wide. Leaves are rough on the upper surface and smooth on the under surface.

Figure 34. Maidencane.

Control Options

Mechanical/Physical

Maidencane can be cut and the rhizomes can be dug up, but physical control is difficult because it can reestablish from seed and remaining rhizomes.

Biological

There is no known biological control for maidencane, although goats are known to forage on many types of emergent vegetation.

Chemical

The only active ingredient that has been very successful in treating maidencane is glyphosate.

Rodeo, **Aquamaster**, **Eraser AQ**, **Touchdown Pro**, and **AquaNeat** are liquid glyphosate formulations and have been effective on maidencane. These are broad spectrum, systemic herbicides. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides. An aquatically registered surfactant (see the label) will have to be added to the glyphosate solution for good results.

One danger with any chemical control method is the chance of an oxygen depletion after the treatment caused by the decomposition of the dead plant material. Oxygen depletions can kill fish in the pond. If the pond is heavily infested with weeds it may be possible (depending on the herbicide chosen) to treat the pond in sections and let each section decompose for about two weeks before treating another section. Aeration, particularly at night, for several days after treatment may help control the oxygen depletion.

Prairie Cordgrass (*Spartina pectinata*)

Prairie cordgrass (or sloughgrass) forms a thick sod in low, wet soils. It grows up to 2 meters tall and can be cut for hay several times during the summer (Van Bruggen 1992). Prairie cordgrass tolerates high salinity levels, so it is common in salty wetland habitats. Early spring growth in a salt marsh at Quivira National Wildlife Refuge, south-central Kansas.

Wild Rice

Scientific Name	*Zizania aquatica* L.
Common Name	Wild Rice
Family	Poaceae (Grass)
Class	Monocot
Description	True annual, overwinters as seed, tall emergent (10 ft.) with long tapering leaves, panicle is large loose head, prolific seed producer
US Distribution	Northern North America; other species throughout US
Worldwide Distribution	Circumboreal
Ecology	Shallow emergent areas, requires water for seed germination
Economic Importance	Important crop for First nation; commercially produced; tropical rice (*Oryza sativa*) is possibly the most important crop worldwide, and is grown originally as an aquatic
Ecological Importance	Highly significant food source for waterfowl
Notes	Native Texas wild rice (*Z. texana*) is on endangered species list

Southern Watergrass

Stems are branched and the underwater portion is usually leafless (Figure 35). Floating leaf blades are 2 to 4 inches long and 1/8 to ¼ inch wide.

Figure 35. Southern Watergrass.

Southern Watergrass
Control Options
Mechanical/Physical - Southern watergrass can be cut and the roots can be dug up but physical control is difficult because it can reestablish from seeds and remaining roots.
Biological - There is no known biological control for southern watergrass, although goats are known to forage on many types of emergent vegetation.
Chemical - The active ingredients that have been successful in treating southern watergrass include glyphosate (*E*) and fluridone (*G*). *E = excellent, G = good*

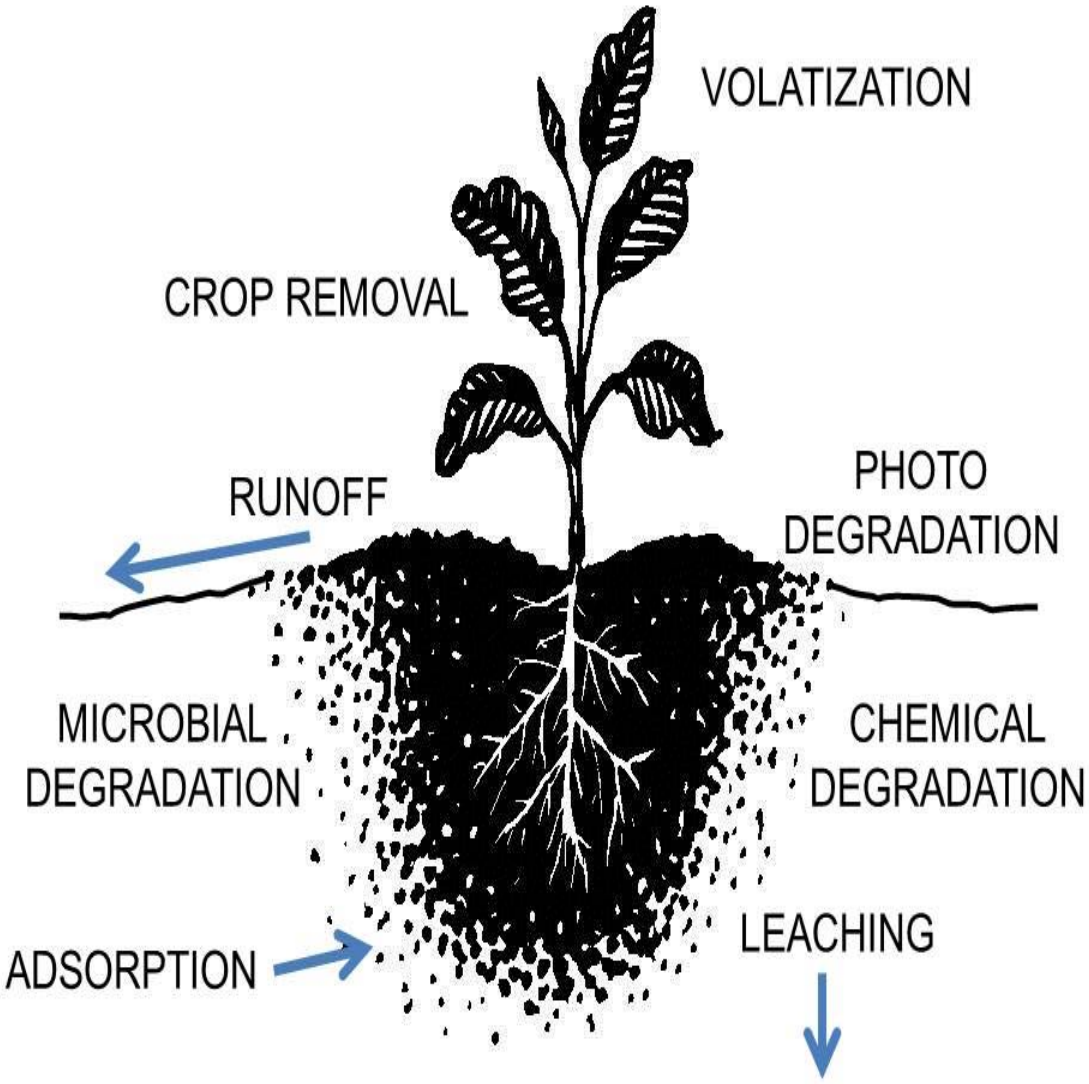
Rodeo**, **Aquamaster**, and **Aquaneat are liquid glyphosate formulations and have been effective on southern watergrass. These are broad spectrum, systemic herbicides. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides. An aquatically registered surfactant (see the label) will have to be added to the glyphosate solution for good results.

Sonar and ***Avast*** are fluridone compounds, come in both liquid and granular formulations, and have been effective on southern watergrass. These are broad spectrum, systemic herbicides. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides.

One danger with any chemical control method is the chance of an oxygen depletion after the treatment caused by the decomposition of the dead plant material. Oxygen depletions can kill fish in the pond. If the pond is heavily infested with weeds it may be possible (depending on the herbicide chosen) to treat the pond in sections and let each section decompose for about two weeks before treating another section. Aeration, particularly at night, for several days after treatment may help control the oxygen depletion.

One common problem in using aquatic herbicides is determining area and/or volume of the pond or area to be treated. Always read and follow all label directions. Check label for specific water use restrictions.

Cultivation Options
Southern watergrass can be propagated by transplanting whole plants into moist soils during the winter or early spring.



PESTICIDE DEGRADATION DIAGRAM

Topic 8 Introduction to Wetlands Section
Answers at the rear of Glossary

Fill-in-the-blank

Economic Importance

1. Low oxygen conditions develop beneath water hyacinth mats and the dense floating mats impede water flow and create good breeding conditions for mosquitoes. _____are a severe environmental and economic problem in all of the gulf coast states and in many other areas of the world with a sub-tropical or tropical climate. This species has rapidly spread throughout inland and coastal freshwater bays, lakes, and marshes in the United States and in other countries.

2. Bladderworts are free-floating plants, but usually go unnoticed due to their habit of hanging out near the bottom in shallow areas. They usually attract attention in spring and summer when they float to the surface to send up shoots of small, attractive,_____. The scientific name for the bladderworts is *Utricularia*. A few species are native, the two most common being *Utricularia vulgaris* or common bladderwort, and *Utricularia minor* or lesser bladderwort.

Control

3. Decades of university, state, and federal research and experience with *Pistia stratiotes* in the U.S. has led to the development of several methods to help in its management: mechanical harvesters and chopping machines remove _____from the water and transport it to disposal on shore; chopping machines grind the plant into bits and spray the slurry across the water.

4. Navigate and Aqua-Kleen are _____that have been effective on pickerelweed. 2,4-D compounds are systemic herbicides. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides.

5. _____is a liquid triclopyr formulation that is effective on pickerelweed. It is a selective broadleaf, systemic herbicide. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides. An aquatically registered surfactant (see the label) will improve the effectiveness of triclopyr.

6. _____is a liquid diquat formulation that has been effective on pickerelweed. It is a contact herbicide. Contact herbicides act quickly and kill all plants cells that they contact. A non-ionic aquatically registered surfactant (see the label) will have to be added to the Reward solution for good results.

7. Habitat contains the active ingredient imazapyr, which inhibits the_____. Habitat is a systemic herbicide that is effective on post-emergent floating and emergent aquatic vegetation.

8. Rodeo, Aquamaster, Eraser AQ, Touchdown Pro, and AquaNeat are _____and have been effective on alligatorweed above the water line but ineffective on plants in the water. They are broad spectrum, systemic herbicides. Systemic herbicides are absorbed and move within the plant to the site of action.

9. Sonar and Avast are fluridone compounds, come in both liquid and granular formulations, and have been effective on alligatorweed in the water. These are broad spectrum, systemic herbicides. _____are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides.

10. _____ is effective at low-volume rates and does not contain heavy metals, organochlorides or phosphates, making it safe to humans and livestock. Habitat requires the use of a spray adjuvant when applying on post-emergent vegetation.

Topic 9 Submersed (underwater) Aquatic Weed Section

Plants in this group grow under and up to the water surface. Some submersed plants have seed heads which extend above the surface and may be confused with emersed plants. However, unlike emersed plants, most submersed weeds are dependent upon water for support. When submersed plants are removed from water, they may be limp and unable to support themselves in an upright position. Submersed weeds can be the most difficult group to identify and control, yet are some of the most common weeds interfering with pond uses.

Naiads (*Najas* Spp.)

Naiads are perennial freshwater plants with floating or submerged leaves, or both. They grow in rice fields and other areas where standing water persists from early spring into summer. On mature plants, leaves encircle the stem in whorls of three. Leaves are very narrow, 0.01 to 0.1 inch (0.25 - 2.5 mm) wide and taper at the tips. Stems are 10 to 25 inches (25 to 62.5 cm) long and may branch at the nodes. Tiny axillary flowers emerge from the sheath at the base of the leaf. Plants propagate from seeds or from stems. This group of plants, also known as bushy pondweed is very common. The margins of the leaves have a "sawtooth" appearance, but in some species these teeth are barely visible without magnification. Leaf size and appearance can vary with different species from a small, thread-like (0.4-1.5 inches long and 0.1 inches wide) shape to a broader, saw-like shape (0.4-1.5 inches long and 0.6-2.0 inches wide). The leaves occur opposite and some species have three leaves in each whorl. One of the most wide spread species is southern naiad. This plant is dark green to purple-brown in color. Leaves are 0.3 to 1.8 inches long and 0.2 to 0.3 inches wide. Marginal teeth on the leaves require magnification to be seen. Leaves are usually opposite or in whorls (Figure 36).

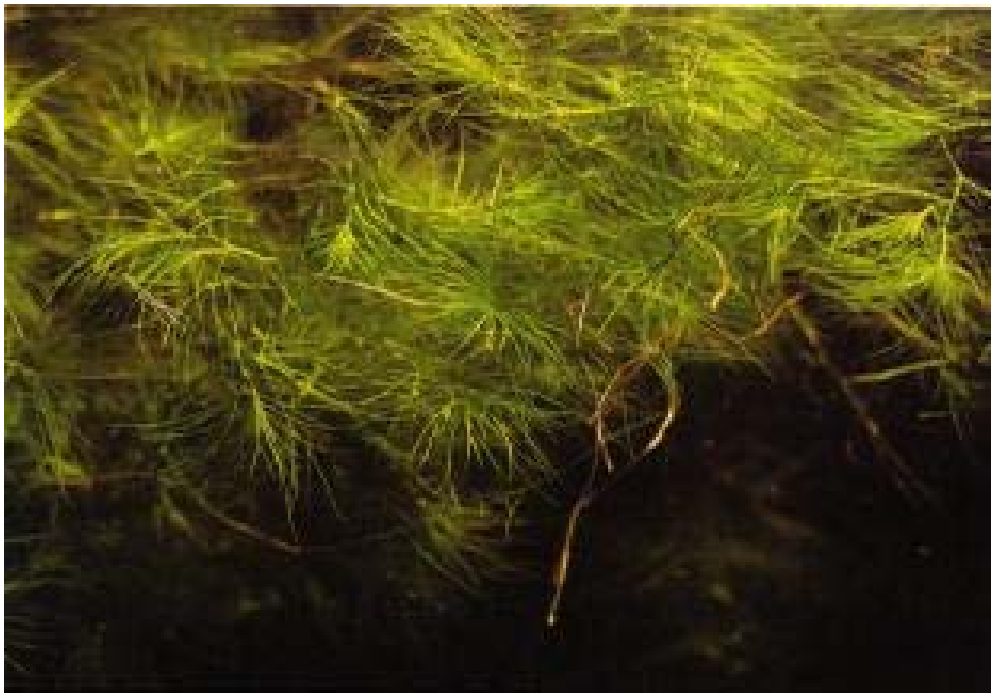


Figure 36. Naiad.

Parrotfeather (*M. brasiliense*)

Parrotfeather is rooted to the bottom but may extend 3 to 12 inches above the water surface (Figure 37). Underwater the stem is quite stout with leaves arranged in whorls with relatively long internodes. Each leaf is 0.8 to 2 inches long and has 10 to 18 narrow comb-like teeth on each side of the mid-rib. Above water, leaves are compacted on shorter internodes and are more delicate in appearance. Above water, leaves are also whorled and vary from yellow to green in color. Parrotfeather is found in most areas of the South.

Figure 37. Parrotfeather.

Mechanical/Physical
Parrotfeather can be removed by raking or seining it from the pond but will reestablish from any remaining fragments and roots.

Fertilization to produce a phytoplankton or algal "bloom" prevents the establishment of most bottom rooted aquatic weeds and produces a strong food chain to the pond fish.

Non-toxic dyes or colorants prevent or reduce aquatic plant growth by limiting sunlight penetration, similar to fertilization. **Aquashade** is an example of non-toxic dye and other products are available. However, dyes do not enhance the natural food chain and may suppress the natural food chain of the pond.

Biological
Grass carp will seldom control aquatic vegetation the first year they are stocked. They will consume parrotfeather but it is not a preferred food. Grass carp stocking rates to control parrotfeather are usually in the range of 7 to 15 per surface acre.

Chemical
The active ingredients that have been successful in treating parrotfeather include 2,4-D (E), diquat (G), copper with diquat (E), endothall (E), triclopyr (G), fluridone (E), and imazapyr (G). E = excellent, G = good

Navigate and **Aqua-Kleen** is a granular butoxyethyl ester of 2,4-D and has been effective on parrotfeather. 2,4-D compounds are systemic herbicides. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides.

Reward is a liquid diquat formulation that has been effective on parrotfeather and is very effective if mixed with a copper compound. It is a contact herbicide. Contact herbicides act quickly and kill all plant cells that they contact.

Cutrine Plus, **K-Tea**, **Captain**, and **Clearigate** are all chelated or compound copper herbicides and can be used in a mixture with Reward or Aquathol K. Other chelated or compound copper formulations are available but are not linked to this web site.

Aquathol, **Aquathol K**, and **Aquathol Super K** are dipotassium salts of endothall and come in both liquid and granular formulations. These endothall products have been effective on parrotfeather and can be mixed with copper compounds for additional effectiveness. Contact herbicides act quickly and kill all plant cells that they contact.

Hydrothol 191 is an alkylamine salt of endothall and comes in both liquid and granular formulations. It is a contact herbicide and has been effective on parrotfeather. Contact herbicides act quickly and kill all plant cells that they contact. Hydrothol can be toxic to fish.

Renovate is a liquid triclopyr formulation that is effective on parrotfeather. It is a selective broadleaf, systemic herbicide. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides. An aquatically registered surfactant (see the label) will improve the effectiveness of triclopyr.

Sonar and **Avast** are fluridone compounds, come in both liquid and granular formulations, and have been effective on parrotfeather. These are broad spectrum, systemic herbicides. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides.

Habitat contains the active ingredient, imazapyr, which inhibits the plant enzyme AHAS (acetohydroxyaced synthase). Habitat is a systemic herbicide that is effective on post-emergent floating and emergent aquatic vegetation. Imazapyr is effective at low-volume rates and does not contain heavy metals, organochlorides or phosphates, making it safe to humans and livestock. Habitat requires the use of a spray adjuvant when applying on post-emergent vegetation.

One danger with any chemical control method is the chance of an oxygen depletion after the treatment caused by the decomposition of the dead plant material.

Oxygen depletions can kill fish in the pond. If the pond is heavily infested with weeds it may be possible (depending on the herbicide chosen) to treat the pond in sections and let each section decompose for about two weeks before treating another section. Aeration, particularly at night, for several days after treatment may help control the oxygen depletion.

Watermilfoil (*Myriophyllum* Spp.)

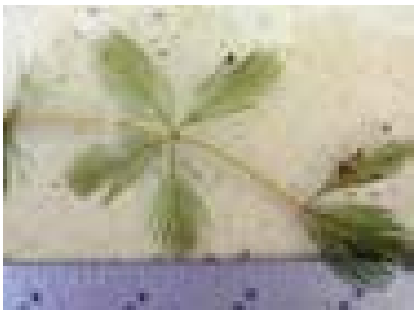
There are several species of *Myriophyllum* common to the Southeast. Generally, this group of plants can be confused with emergent (above water) plants. In some species, the tip may extend 3 to 12 inches above the water. Also, above water leaves may appear to be different from underwater leaves. In all species, underwater leaves are "comb-like" or "feather-like" in appearance and are whorled. Three species are a common management problem in ponds.

Eurasian Watermilfoil (*M. spicatum*)

This species is primarily a problem in the coastal areas of the southeast (Figure 38). This plant is apparently spreading throughout the Southeast. The underwater leaves look like weather-beaten feathers and are whorled. The above water tip has no leaves and may be 2 to 4 inches long.

Figure 38. Eurasian watermilfoil.

Eurasian watermilfoil is a submerged aquatic plant that, when reaching the surface of the water, grows horizontally, creating a mat.



The stem can range from pale pink to red to reddish brown with feathery leaves.

Leaves are divided into leaflets, usually numbering greater than 9 per leaf. The ends of the leaves form a blunt tip, appearing snipped. Between 3 to 5 leaves grow in a whorled pattern around the stem. Many native plants have characteristics that resemble those of invasive aquatic plants. To identify an aquatic plant, begin by observing leaf types and how the leaves are arranged on the plants. Also note any other structures the plant may have such as flowers, fruits, bladders, and root structures.

Accidentally introduced from Europe in the 1940s, Eurasian watermilfoil (Myriophyllum spicatum L.) has become one of the most troublesome submersed aquatic plants in North America. It has spread to at least 45 U.S. states and three Canadian provinces. Although most frequently found in quiet bodies of water (1 - 10 m. deep), it has shown an ability to grow in rapidly flowing water.

The plant has been known to degrade shoreline quality, clog propellers, restrict boat access, impair swimming, increase water temperature, and crowd out important native water plants. In some lakes, however, the plant appears to coexist with native flora and has little impact on fish and other aquatic animals. A variety of physical, chemical, and biological control methods have been used in attempts to manage infestations of Eurasian watermilfoil. Unfortunately, complete eradication is rare.

Mechanical/Physical
Eurasian watermilfoil can be removed by raking or seining it from the pond but will reestablish from any remaining fragments and roots.

Fertilization to produce a phytoplankton or algal "bloom" prevents the establishment of most bottom rooted aquatic weeds and produces a strong food chain to the pond fish.

Non-toxic dyes or colorants prevent or reduce aquatic plant growth by limiting sunlight penetration, similar to fertilization.

Aquashade is an example of non-toxic dye and other products are available. However, dyes do not enhance the natural food chain and may suppress the natural food chain of the pond.

Biological
Grass carp will seldom control aquatic vegetation the first year they are stocked. They will consume Eurasian milfoil but it is not preferred and almost the last thing consumed. Grass carp stocking rates to control Eurasian watermilfoil are usually in the range of 7 to 15 per surface acre or more.

Chemical
The active ingredients that have been successful in treating Eurasian watermilfoil include copper complexes (G), 2,4-D (E), diquat (E), endothall (E),triclopyr (E) and fluridone (G). E = excellent, G = good

Navigate and **Aqua-Kleen** is a granular butoxyethyl ester of 2,4-D and has been effective on Eurasian watermilfoil. 2,4-D compounds are systemic herbicides. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides.

Reward is a liquid diquat formulation that has been effective on Eurasian watermilfoil and is very effective if mixed with a copper compound. It is a contact herbicide. Contact herbicides act quickly and kill all plants cells that they contact.

Renovate is a liquid triclopyr formulation that is effective on eurasian watermilfoil. It is a selective broadleaf, systemic herbicide. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides. An aquatically registered surfactant (see the label) will improve the effectiveness of triclopyr.

Cutrine Plus, **K-Tea**, **Captain**, and **Clearigate** are all chelated or compound copper herbicides and can be used in a mixture with Reward or Aquathol K. Other chelated or compound copper formulations are available but are not linked to this web site.

Aquathol, **Aquathol K**, and **Aquathol Super K** are dipotassium salts of endothall and comes in both liquid and granular formulations. These endothall products have been effective on Eurasian watermilfoil and can be mixed with copper compounds for additional effectiveness. Contact herbicides act quickly and kill all plant cells that they contact.

Hydrothol 191 is an alkylamine salt of endothall and comes in both liquid and granular formulations. It is a contact herbicide and has been effective on Eurasian watermilfoil. Contact herbicides act quickly and kill all plants cells that they contact. Hydrothol can be toxic to fish.

Sonar and **Avast** are fluridone compounds, come in both liquid and granular formulations, and have been effective on Eurasian watermilfoil. These are broad spectrum, systemic herbicides. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides.

One danger with any chemical control method is the chance of an oxygen depletion after the treatment caused by the decomposition of the dead plant material. Oxygen depletions can kill fish in the pond. If the pond is heavily infested with weeds it may be possible (depending on the herbicide chosen) to treat the pond in sections and let each section decompose for about two weeks before treating another section. Aeration, particularly at night, for several days after treatment may help control the oxygen depletion.

Broadleaf Watermilfoil (*M. heterophyllum*)

Broadleaf watermilfoil (not illustrated) is more coarse in appearance than parrot feather. Underwater leaves are also whorled and sparse. Above water, the spike may be 2 to 6 inches long. Leaves are also whorled above water but do not have a feather-like appearance. They may be 0.2 to 1.2 inches long and are serrated along the edges.

Mechanical/Physical
Variable-leaf watermilfoil can be removed by raking or seining it from the pond but will reestablish from any remaining fragments and roots.

Fertilization to produce a phytoplankton or algal "bloom" prevents the establishment of most bottom rooted aquatic weeds and produces a strong food chain to the pond fish.

Non-toxic dyes or colorants prevent or reduce aquatic plant growth by limiting sunlight penetration, similar to fertilization. **Aquashade** is an example of non-toxic dye and other products are available. However, dyes do not enhance the natural food chain and may suppress the natural food chain of the pond.

Biological
Grass carp will seldom control aquatic vegetation the first year they are stocked. They will consume variable-leaf milfoil but it is not preferred. Grass carp stocking rates to control variable-leaf watermilfoil are usually in the range of 7 to 15 per surface acre or more.

Chemical
The active ingredients that have been successful in treating variable-leaf watermilfoil include copper complexes (G), 2,4-D (E), diquat (E), endothall (E), triclopyr (E) and fluridone (G). E = excellent, G = good

Navigate and **Aqua-Kleen**is a granular butoxyethyl ester of 2,4-D and has been effective on variable-leaf watermilfoil. 2,4-D compounds are systemic herbicides. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides.

Reward is a liquid diquat formulation that has been effective on variable-leaf watermilfoil and is very effective if mixed with a copper compound. It is a contact herbicide. Contact herbicides act quickly and kill all plant cells that they contact.

Cutrine Plus, **K-Tea**, **Captain**, and **Clearigate** are all chelated or compound copper herbicides and can be used in a mixture with Reward or Aquathol K. Other chelated or compound copper formulations are available but are not linked to this web site.

Aquathol, **Aquathol K**, and **Aquathol Super K** are dipotassium salts of endothall and comes in both liquid and granular formulations. These endothall products have been effective on variable-leaf watermilfoil and can be mixed with copper compounds for additional effectiveness. Contact herbicides act quickly and kill all plants cells that they contact.

Hydrothol 191 is an alkylamine salt of endothall and comes in both liquid and granular formulations. It is a contact herbicide and has been effective on variable-leaf watermilfoil. Contact herbicides act quickly and kill all plant cells that they contact. Hydrothol can be toxic to fish.

Renovate is a liquid triclopyr formulation that is effective on variable leaf watermilfoil. It is a selective broadleaf, systemic herbicide. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides. An aquatically registered surfactant (see the label) will improve the effectiveness of triclopyr.

Sonar and **Avast** are fluridone compounds, come in both liquid and granular formulations, and have been effective on variable-leaf watermilfoil. These are broad spectrum, systemic herbicides. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides.

One danger with any chemical control method is the chance of an oxygen depletion after the treatment caused by the decomposition of the dead plant material. Oxygen depletions can kill fish in the pond. If the pond is heavily infested with weeds it may be possible (depending on the herbicide chosen) to treat the pond in sections and let each section decompose for about two weeks before treating another section. Aeration, particularly at night, for several days after treatment may help control the oxygen depletion.

Elodeas

Included in this group are hydrilla (*Hydrilla verticillata*), egeria or Brazilian elodea (*Egeria densa*) and elodea (*Elodea canadesis*). Hydrilla is a significant problem in Florida and is becoming established in many of the other Southern states (Figure 39). Egeria is more common in Florida but is also established in other areas (Figure 40). Elodea is more common to Northern and Midwestern states and is occasionally found in the Southeast.

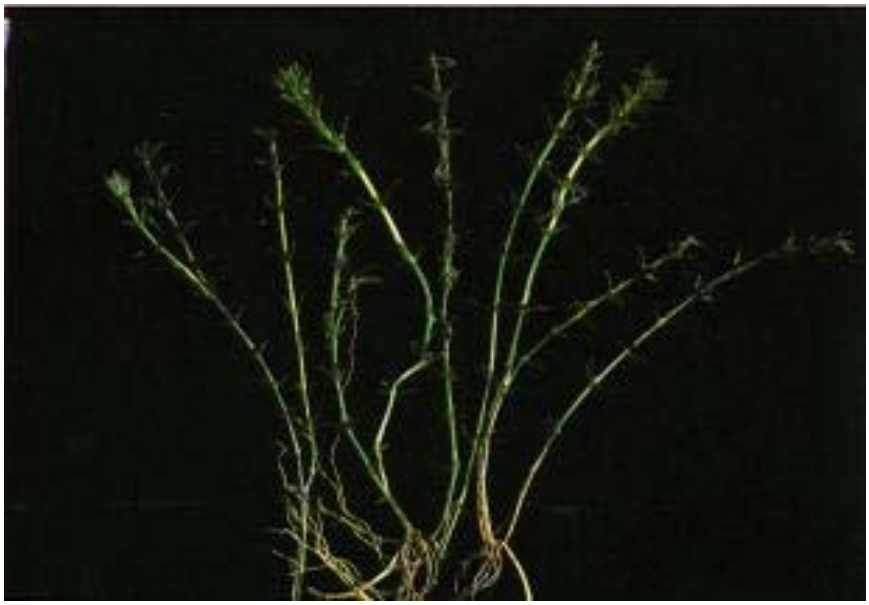


Figure 39. Hydrilla.

Figure 40. Egeria.

Hydrilla is a serious threat to fresh water habitats and for this reason it should be distinguished from egeria. The midrib of hydrilla leaves may be red. Leaf margins have strong serrations and large soft spines on the back of the midrib. Usually hydrilla has a harsh scratchy texture while egeria lacks these characteristics.

Hydrilla is very difficult to identify because of the variable characters it has in different habitats. Any aquatic plant identified as egeria, elodea, or hydrilla should be sent to a specialist for positive identification since hydrilla is such a serious threat to fresh water habitats. It is only through early identification and concentrated control methods that there is any hope of eliminating hydrilla. Fishermen or boaters in waters known to have hydrilla should make every effort not to accidentally transport hydrilla from one lake or pond to another.

Scientific Name	*Hydrilla verticillata* (L.f.) Royle
Common Name	Hydrilla
Family	Hydrocharitaceae (Frogbit)
Class	Monocot
Description	Perenniating mostly from tubers, propagates from tubers, turions, root crowns, and fragments; partially evergreen; white flowers
US Distribution	Diocieous form: southeastern US, Texas, California. Monoecious form: Maryland, North Carolina, Virginia, Delaware, California.
Worldwide Distribution	Scattered subtropical regions: Australia, China, US, New Zealand; native of China
Ecology	Submersed in 1 up to 20 feet depth
Economic Importance	Major nuisance impact on US systems ($8M/yr in Florida)
Ecological Importance	Major impact on aquatic ecosystems
Notes	Has both monoecious and diocieous forms; no sexual propogation in diocieous form

Mechanical/Physical
Elodea can be removed by raking or seining it from the pond but will reestablish from any remaining fragments and roots.

Fertilization to produce a phytoplankton or algal "bloom" prevents the establishment of most bottom rooted aquatic weeds and produces a strong food chain to the pond fish.

Non-toxic dyes or colorants prevent or reduce aquatic plant growth by limiting sunlight penetration, similar to fertilization. **Aquashade** is an example of non-toxic dye and other products are available. However, dyes do not enhance the natural food chain and may suppress the natural food chain of the pond.

Biological
Grass carp will seldom control aquatic vegetation the first year they are stocked. They will readily consume elodea. Grass carp stocking rates to control elodea are usually in the range of 7 to 15 per surface acre.

Chemical
Active ingredients that have been successful in treating elodea include diquat (E) and fluridone (E). E = excellent, G = good

Reward is a liquid diquat formulation that has been effective on elodea. It is a contact herbicide. Contact herbicides act quickly and kill all plant cells that they contact.

Sonar and **Avast** are fluridone compounds and come in both liquid and granular formulations and have been effective on elodea. These are broad spectrum, systemic herbicides. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides.

One danger with any chemical control method is the chance of an oxygen depletion after the treatment caused by the decomposition of the dead plant material. Oxygen depletions can kill fish in the pond. If the pond is heavily infested with weeds it may be possible (depending on the herbicide chosen) to treat the pond in sections and let each section decompose for about two weeks before treating another section. Aeration, particularly at night, for several days after treatment may help control the oxygen depletion.

This course contains EPA's federal rule requirements. Please be aware that each state implements pesticide regulations that may be more stringent than EPA's regulations and these frequently are changed. Check with your state environmental/pesticide agency for more information.

Fanwort (*Cabomba* Spp.)

The submersed leaves of fanwort are "fan-like" in shape and made up of many thread-like elements (Figure 41). The stem may be covered with a gelatinous material. The floating leaves are few and of different shapes. Floating leaves may be long and narrow or oval in shape.

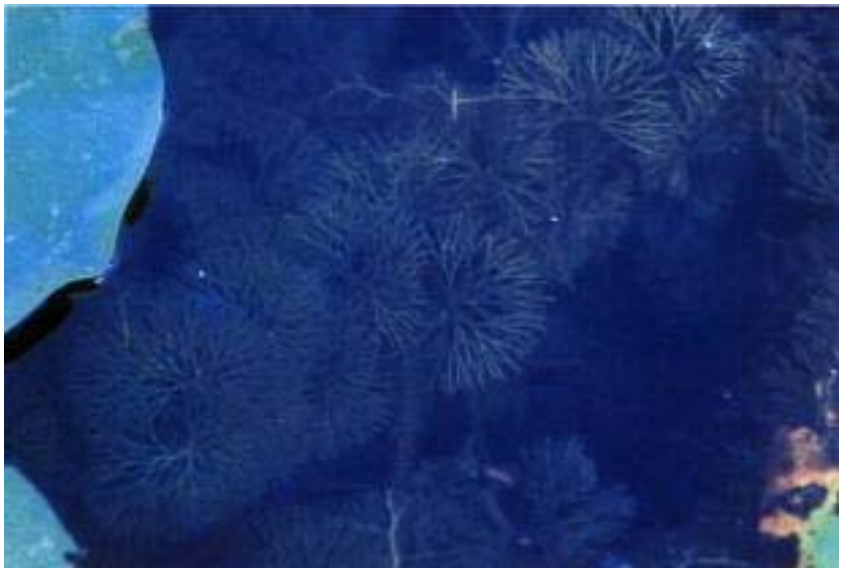
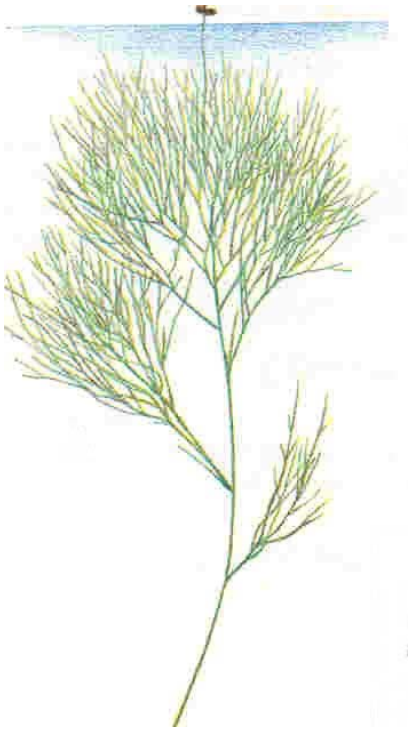


Figure 41. Fanwort.



Sago Pondweed

Sago Pondweed

Scientific Name	*Potamogeton pectinatus* L.
Common Name	Sago Pondweed
Family	Potamogetonaceae (Pondweed)
Class	Monocot
Description	Submersed rooted, alternate long narrow leaves with distinct point, flowers emergent and inconspicuous, wind or water pollinated, reproduces by stolons and both subterranean and auxiliary tubers
US Distribution	Throughout North America
Worldwide Distribution	Almost worldwide
Ecology	Submersed in both static and flowing waters
Economic Importance	May form nuisance growths in eutrophic streams and ditches
Ecological Importance	Highly important habitat and food for waterfowl and aquatic organisms, waterfowl eat tubers, foliage, and seeds
Notes	Then genus and family are the most important taxa to submersed aquatic communities in North America, and possibly worldwide

Mechanical/Physical
Sago pondweed can be removed by raking or seining it from the pond but will reestablish from any remaining roots and seeds.

Fertilization to produce a phytoplankton or algal "bloom" prevents the establishment of most bottom rooted aquatic weeds and produces a strong food chain to the pond fish.

Non-toxic dyes or colorants prevent or reduce aquatic plant growth by limiting sunlight penetration, similar to fertilization.

Aquashade is an example of non-toxic dye and other products are available. However, dyes do not enhance the natural food chain and may suppress the natural food chain of the pond.

Biological
Grass carp will seldom control aquatic vegetation the first year they are stocked. They will readily consume sago pondweed. Grass carp stocking rates to control sago pondweed are usually in the range of 7 to 15 per surface acre.

Chemical
The active ingredients that have been successful in treating sago pondweed include diquat (G), copper with diquat (G), endothall (E), and fluridone (E). E = excellent, G = good

Reward is a liquid diquat formulation that has been effective on sago pondweed and is very effective if mixed with a copper compound. It is a contact herbicide. Contact herbicides act quickly and kill all plant cells that they contact.

Cutrine Plus, **K-Tea**, **Captain**, and **Clearigate**are all chelated or compound copper herbicides and can be used in a mixture with Reward or Aquathol K. Other chelated or compound copper formulations are available but are not linked to this web site.

Aquathol, **Aquathol K**, and **Aquathol Super K** are dipotassium salts of endothall and comes in both liquid and granular formulations. These endothall products have been effective on sago pondweed and can be mixed with copper compounds for additional effectiveness. Contact herbicides act quickly and kill all plant cells that they contact.

Hydrothol 191 is an alkylamine salt of endothall and comes in both liquid and granular formulations. It is a contact herbicide and has been effective on sago pondweed. Contact herbicides act quickly and kill all plants cells that they contact. Hydrothol can be toxic to fish.

Sonar and **Avast** are fluridone compounds, come in both liquid and granular formulations, and have been effective on sago pondweed. These are broad spectrum, systemic herbicides. Systemic herbicides are absorbed and move within the plant to the site of action.

Systemic herbicides tend to act more slowly than contact herbicides.

One danger with any chemical control method is the chance of an oxygen depletion after the treatment caused by the decomposition of the dead plant material.

Oxygen depletions can kill fish in the pond. If the pond is heavily infested with weeds it may be possible (depending on the herbicide chosen) to treat the pond in sections and let each section decompose for about two weeks before treating another section. Aeration, particularly at night, for several days after treatment may help control the oxygen depletion.

Pondweeds (*Potamogeton* Spp.)

Pondweeds are the largest group of aquatic plants (Figures 42, 43). Different species are quite varied in their appearance. Some members of this group are very difficult to control. In many species, the leaves are usually alternate and the underwater leaves are often ribbon-like and less firm in texture than the floating leaves. The flowers and fruits are on spikes extending above the water surface. Leaves may vary from thread-like to large oval-or lance-shaped.

Figure 42. Pondweed.

Figure 43. Pondweed.

Aquatic Life Evaluation Section

Evaluating a pond is a simple, critical, and often overlooked step in the successful control of aquatic weeds. An evaluation of the pond will help the owner select and apply the most efficient, effective, and economical control measure. A pond evaluation should include the following: an inventory of pond water and watershed uses; an appraisal of the physical conditions of the pond and watershed; knowledge of some of the water chemistry; and the pond water volume.

Pond and Watershed Uses
Most pond owners already know the various uses of their pond and watershed. However, pond and watershed uses need to be considered when attempting to control aquatic weeds. This is especially true if herbicides are used. For example, aquatic herbicides applied to a pond used for irrigation may have a disastrous effect upon the irrigated crops. In most instances, a conflicting water use (such as irrigation) can be temporarily stopped until the herbicide has dissipated from the water. In other situations, this may not be practical and an alternative control measure should be used. If herbicides are used, water uses should be compared to restrictions listed on the label. Some water uses which may interfere with aquatic weed control are: irrigation, boating, swimming, watering livestock, sport fishing and commercial fish production.

Physical Conditions
Various physical conditions may contribute to an aquatic weed problem or interfere with attempts to control it. Ponds which have extensive areas of shallow water or receive organic runoff usually have aquatic weed problems. Attempts to control weeds in these ponds are usually unsuccessful unless the pond is deepened or the source of organic runoff is removed or diverted around the pond. Deepening a pond or eliminating organic runoff can be considered control methods and are discussed in the "*Methods of Aquatic Weed Control"* section. Excessive amounts of water flowing through a pond can interfere with aquatic weed control. Ponds which are constructed on constantly flowing streams, or have an excessively large watershed, or have a large number of springs can be difficult to manage for aquatic weeds. Excessive water flow may interfere with the following weed control measures: fertilization, herbicides, and fall-winter drawdowns.

Pond Water Chemistry
When controlling aquatic weeds with herbicides or fertilizer, it is important to know something about the chemistry of the water in the pond. Water hardness can affect herbicide and fertilizer applications. The water hardness also should be considered when using herbicides containing copper. Water hardness--Generally, water hardness is a measure of the calcium and magnesium in the water. In hard waters (above 50 parts per million hardness) it may be necessary to apply greater amounts of herbicide in order to achieve control. In soft waters (below 50 parts per million hardness) some herbicides are more toxic to fish and plants. Herbicides which may be affected by water hardness have precautions listed on their labels. Water hardness is also an indicator of the lime requirement for the pond. See the section on Pond Fertilization. Many areas of the south have soft water. Pond owners should be familiar with the water hardness of their pond. Pond water hardness can be measured by most state Extension services or state game and fish departments. Copper--In soft water some heavy metals, especially copper, can be toxic to fish. Some herbicides contain copper and should be used with caution in soft water ponds (less than 50 parts per million water hardness).

Pond Water Volume
Pond owners should know the water volume of their ponds. Most chemical application rates are based upon water volume. This is true for chemicals used to treat aquatic weeds, fish diseases, and oxygen depletions. The volume of water in a pond is usually expressed in acre-feet. An acre-foot of water is one surface acre that is one foot deep. A pond having three surface acres and an average depth of 6 feet has a total water volume of 18 acre-feet. Table 1 can be used to convert acre-feet to other expressions of volume and weight.

Most county Soil Conservation Service offices can assist pond owners in determining the water volume of their ponds. Assuming the surface area of the pond is known, the following method can be used to determine the average depth of a pond. Average depth can be determined by use of a sounding line at regular intervals along several transects of the pond. Both deep and shallow areas of the pond should be included in the transects. Average depth is computed by adding all of the depth measurements and dividing by the number of measurements. The average depth multiplied by the surface area should give an accurate estimate of the pond water volume.

Table 1. Equivalents of I acre-foot and amount of chemical added per unit volume to give one part per million (ppm) (Conversion Factor).

1 acre foot = 43,560 cubic feet	1 ppm = 2.72 pounds per acre foot
1 acre foot = 325,830 gallons of water	
1 acre foot = 2,718,144 pounds of water	

Methods of Aquatic Weed Control

Methods of aquatic weed control include preventive measures, as well as mechanical, biological, and herbicidal controls. Each method has advantages and disadvantages. The best approach is to consider preventive measures first. If they are not practical or do not produce the desired results, then other control methods should be considered. It is always easier and more economical to prevent a weed problem than to cure one. Even when preventive measures are only partially successful, they quite often facilitate the effectiveness of other control measures.

Preventative Measures

Preventive measures include proper pond location and construction, fertilization and fall-winter drawdowns. If one or all of these practices are followed, the need for herbicide use in many southern ponds will be reduced.

Pond Location

Careful selection of a pond site can help prevent weed problems. A flowing stream is not a good location for the construction of a pond. Excessive water flow will prevent successful fertilization and complicate herbicide applications. This is also true of ponds with excessive watershed-to-pond surface area ratios. The recommended watershed-to-pond ratio depends on land use, vegetative cover, soil type, and slope of the land. Generally, a watershed of 10 to 20 acres per surface acre of pond is recommended for woodland, while 5 to 10 acres is recommended for pastureland.

Construction of ponds in watersheds that have highly fertilized fields, barn lots, septic tank fields, or other sources of organic runoff should be avoided. Enrichment of a pond with organic material will promote weed growth. Existing ponds with excessively large watersheds or sources of organic pollution in the watershed may benefit from the construction of a diversion ditch to direct some of the runoff around the pond.

Pond Construction

Most algae and submersed or emersed rooted aquatic weeds usually start growing in shallow water 2 feet deep or less. Once established, they will often extend into deeper water areas. Ponds should be constructed so there is little, if any, water less than two feet deep. In existing ponds, it may be practical to deepen shallow water areas.

Fertilization

In properly constructed ponds, establishment and growth of aquatic weeds is best prevented by fertilization. Fertilization stimulates the growth of desirable algae so sunlight cannot penetrate to the bottom and rooted aquatic weeds cannot become established (Figures 44, 45). In ponds with established aquatic weeds, these plants generally die down during the winter. If fertilization is begun before weeds begin spring growth, in most instances they will not become re-established.

If fertilization is begun after weeds have become established, fertilizer will be taken up by the weeds. This will produce heavier weed growth. Fertilization should begin as early as possible in spring before weed growth starts.

Herbicidal Treatment
Herbicidal treatment of a weed problem in the spring followed by a fertilization program is often a good weed control measure. In some areas of the southeast, pond fertilization may not be recommended or recommendations described below may be modified because of area differences in watershed uses and fertility. For local fertilizer recommendations, consult with your county Extension agent or state game and fish personnel.

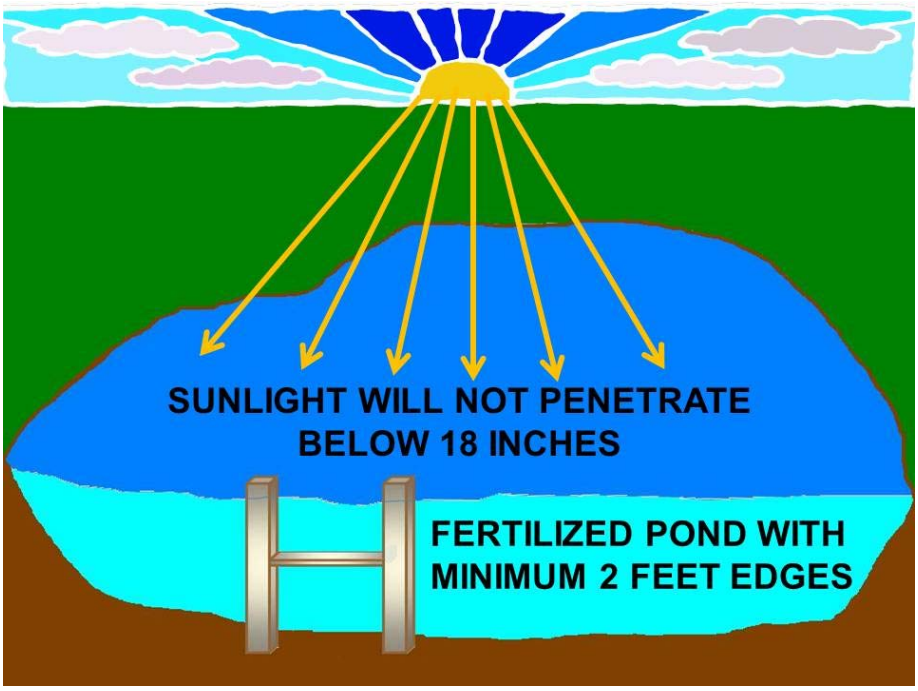


Figure 44.

2017 Changes to EPA's Worker Protection Standard

In late 2015 the Environmental Protection Agency issued the long awaited revision to the Worker Protection Standard (WPS). This law it is now technically active and it will be enforced. Please keep in mind that the WPS covers both restricted use AND general use pesticides. This course is not for worker and/or handler training. Always follow the label and your State Pesticide Agency rules.

This course contains EPA's federal rule requirements. Please be aware that each state implements pesticide regulations that may be more stringent than EPA's regulations and these frequently are changed. Check with your state environmental/pesticide agency for more information.

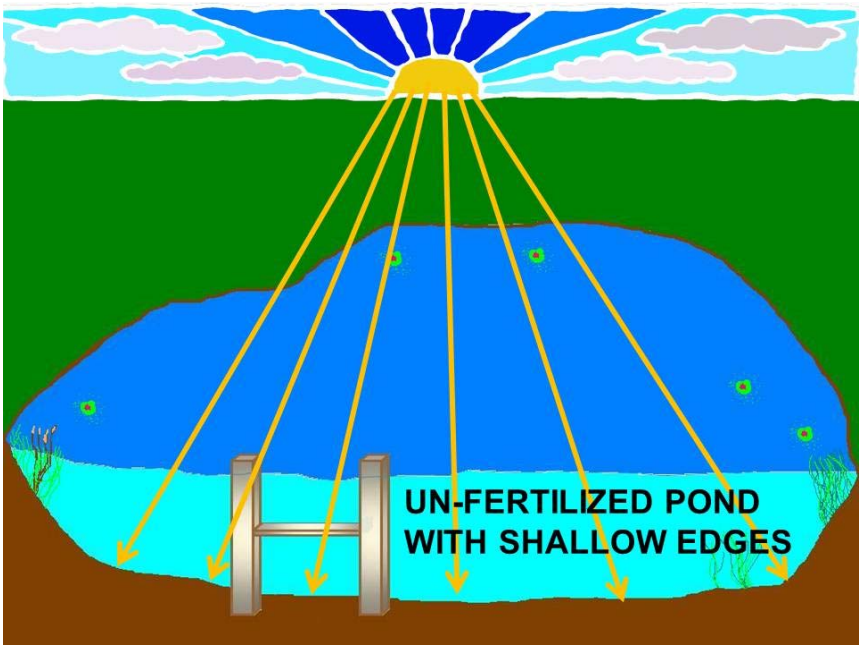


Figure 45.

Begin fertilizing with 40 pounds of 20-20-5 per surface acre in late February or early March when water temperature stabilizes above 60°F. If after two weeks you can see a bright object more than 18 inches beneath the surface, proper water color resulting from plankton algae growth has not been developed. Fertilize again at the same rate.

If proper color does not develop following the third application, test the pond for lime requirements. Proper color can be maintained by fertilizing with 40 pounds of 20-20-5 per surface acre when a bright object can be seen more than 18 inches into the water. Fertilization will probably be necessary about once a month. Stop fertilization when water temperature stabilizes below 65°F. This is usually in October or November.

Method of Application

The most economical method of application is to pour the fertilizer on a platform constructed 12 to 18 inches below the water surface (Figure 46). There should be at least three square feet of platform for each surface acre in the pond. Fertilizer placed on platforms will dissolve slowly in the upper layer of water (where desirable algae production occurs) and will be distributed by wind. Locate the platform 10 to 15 feet from the shore so the fertilizer will receive maximum wind distribution.

Other acceptable methods of application include: broadcasting fertilizer by hand in shallow water less than four feet deep, or pouring it in a line 15 feet from shore in shallow areas, or slitting fertilizer bags and placing them in shallow water.

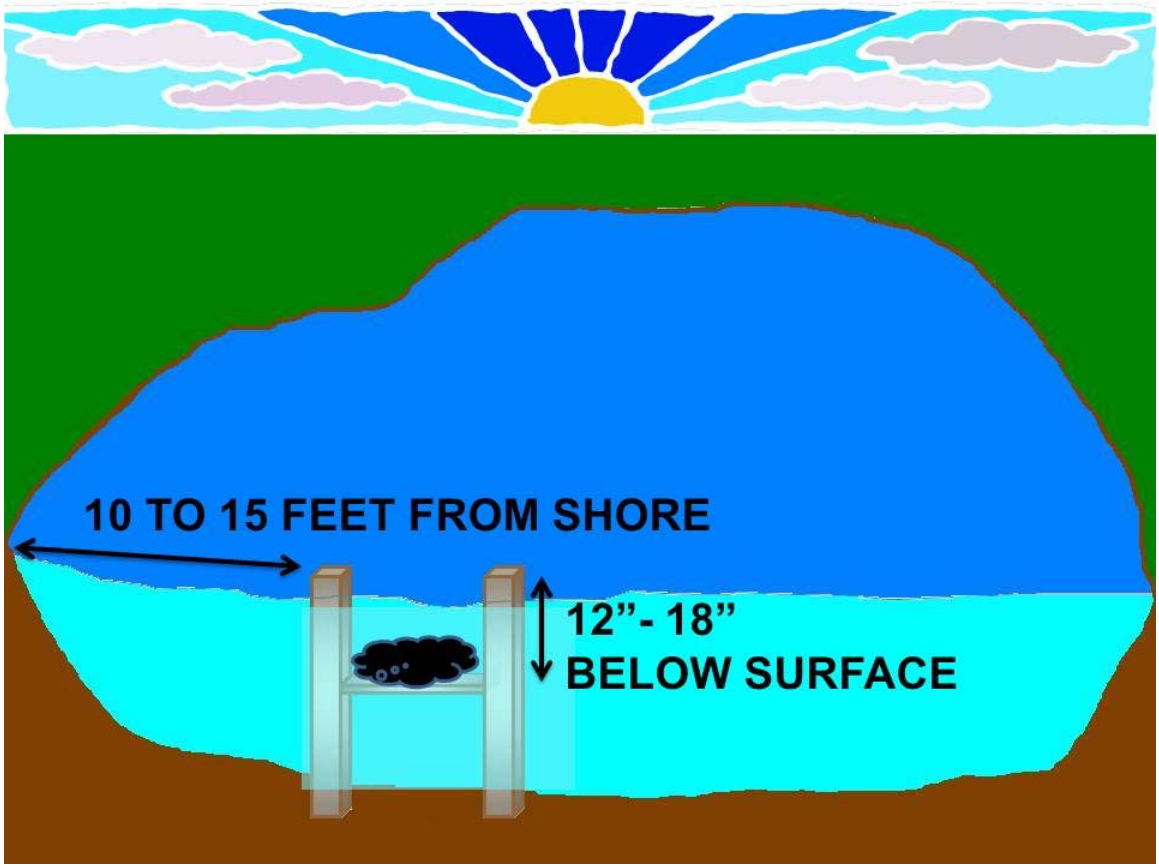


Figure 46. Fertilizer platform.

Liming

Lime is as necessary for plant production in ponds as it is on fields. Soft water ponds should be limed before fertilization, this can be effective in producing a bloom of desirable algae. Many Southern ponds should be limed every two to four years.

Liming requirements can be determined by your county Extension agent or state game and fish personnel. Agricultural lime is used for liming ponds. Although agricultural lime may be added at any time, it takes about three months for it to go into solution. Lime should be distributed throughout the pond during fall so it will be in solution the following spring when fertilization begins.

Fall-Winter Drawdown

Decreasing the water level of a pond is called a drawdown. Drawdowns are beneficial in controlling weeds and correcting mildly crowded bream populations. If a drawdown is used for two or four consecutive years, as much as 90 percent of the submerged vegetation in a pond can be eliminated. Drawdowns expose the shallow areas of a pond to winter weather and drying, thus eliminating some of the weeds (Figure 47). A pond should be drawn down in November and this lowered water level maintained until spring (February or March). Drawdowns should never be used in warm weather months or in ponds smaller than one surface acre. The pond water surface area should be reduced at least one-third and not more than one-half.

Figure 47. Fall-winter drawdown.

Mechanical Methods

Some rather sophisticated machines have been developed to control aquatic weeds. These machines either cut or drag weeds from a pond. Unfortunately their operation is expensive and not practical for most privately owned ponds. Seining or raking weeds out of the water can be an effective control method in small ponds.

Because of the labor involved, it is not practical in larger bodies of water. Seining or raking weeds can be used to temporarily clear small shallow bays or beach areas in large ponds. Sun screening or shading materials have been used to successfully control weeds in some ponds. These materials either restrict or shade-out plant growth. Generally, their use is not practical in large ponds. Black plastic sheeting, for example, can be spread out and weighted down on the bottom in a swimming beach area to control submersed weeds. This plastic should be left in place for about two weeks in order to achieve temporary control.

Biological Control Methods

Biological controls of aquatic weeds are a new and promising development in pond management. A biological control is some living agent, whether it is fish, insect, or bacteria, which is harmful to and attacks the nuisance aquatic plant. Most biological agents are organisms which are not native to this country and thus must be studied to determine whether they may have any negative effects upon the environment prior to release. In some states, the grass carp or white amur (Ctenopharyngodon idella) is being used to aid in control of aquatic weeds (Figure 48). The grass carp is not a native fish to this country. The use of grass carp for aquatic weed control is presently highly controversial. It is the general opinion of many biologists that the grass carp is a potential hazard to our native fish and waters and not enough information is available to recommend its use. In most states it is illegal to stock this fish. Do not stock grass carp in ponds in states where their use is prohibited. And, never stock the fish without first consulting with state game and fish department personnel or a qualified fisheries biologist.

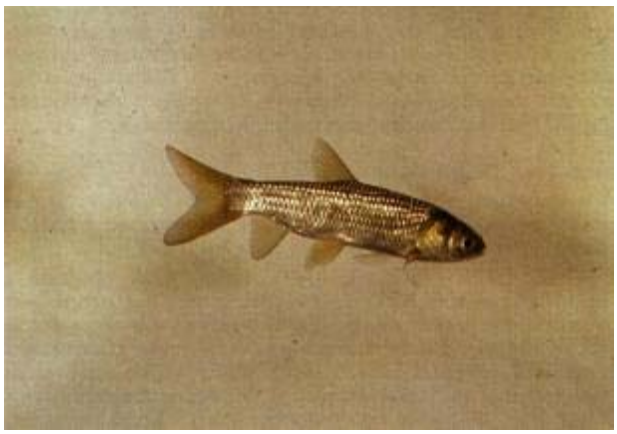


Figure 48. Grass carp.

Chemical Methods

Aquatic herbicides are safe and effective if they are selected and applied properly. Choosing the right herbicide does not guarantee success. It must also be applied properly and all warnings and precautions concerning use should be understood and observed. Fortunately, all of this information is on the herbicide label. Anyone who uses an aquatic herbicide should always thoroughly read and understand the herbicide label before purchasing and applying the chemical.

County extension agents and state fisheries biologists can advise pond owners who have questions concerning aquatic herbicide selection, methods and rates of application, precautions, and state and federal regulations. The information in this section is not intended to replace the information on the herbicide label. Rather, it should be used to supplement label information.

Selection of an Aquatic Herbicide

Identification of the weed, knowledge of pond water volume or surface area, and water uses will help the pond owner select the most effective and economic aquatic herbicide.

Weed Identification

No single aquatic herbicide is capable of controlling all kinds of weeds that are potential problems in the management of a pond. For this reason, it is important to identify the weed before attempting to control it with a herbicide. Herbicide labels list the aquatic weeds which will respond to treatment with that particular herbicide. Table 2 lists the aquatic weeds described in this publication and the herbicides which are usually effective in their control.

Pond Water Volume and Surface Area
Herbicide application rates are determined either by the pond's water volume or by surface area. Most herbicide labels list application rates according to one or the other of these measures. Some herbicide application rates will vary depending upon the weed species and the extent of infestation. Prior knowledge of the pond's water volume and surface area will aid in the selection of the most economical herbicide and insure the proper amount is purchased and applied.

Pond Water Uses
Restrictions and cautions of herbicide use will vary depending upon the herbicide. This information is on the herbicide label. If pond water uses are not compatible with the restrictions and cautions listed for a specific herbicide, an alternate herbicide should be selected, or another aquatic weed control measure used.

Herbicide Application
It is not enough to select the right herbicide. The herbicide must also be applied properly. The herbicide applicator must be knowledgeable of the herbicide formulation, methods and rates of application, precautions and warnings, and other information specific to the herbicide.

Formulation
Herbicide formulations vary in the amount of active ingredients present. The active ingredients are the chemicals which actually kill the pest or weed. Inert ingredients are added to improve the convenience, safety, and handling of the herbicide. Herbicide application rates are based upon the active ingredient in the herbicide formulation. This is one reason why it is always important to determine herbicide application rates from information printed on the label.

Methods of Application
Some herbicides can be applied directly from the container (ready for use) and others need to be diluted with water or some other dilutent before application. Always follow label directions. Dispersion of the herbicide is also important. In small ponds, for shoreline areas or "spot treatments," many of the herbicides can be applied by simply broadcasting the chemical over the area. Most of the granular formulations can be scattered directly. In small areas, some liquid formulations can be poured over the area but others need to be diluted and may be applied with a sprinkling can. Treatment of large areas usually require the use of mechanical sprayers or spreaders and a boat with an outboard motor to ensure that the chemical is adequately dispersed.

Most aquatic herbicides can be applied with a hand operated seeder, pressurized sprayer, or boat bailer. Injecting the chemical near the outboard motor prop wash will help in dispersion. Some herbicides are "contact killers," that is, they must come into direct contact with the plant. For this reason, contact herbicides must be evenly dispersed in or on the water to have maximum effectiveness. Other herbicides must be absorbed by the plant to be effective and are called "translocated" herbicides.

Floating Weeds
Control of floating weeds usually requires a surface spray application as the least expensive method, as compared with treatment of the total volume of water.

Emersed (above water) Weeds
Control of emersed weeds may permit a choice of methods, depending upon the specific weed. If a large portion of the leaf area is above water, surface spray applications may be the most effective and least expensive method. Application of aquatic granules or pellets may also be substituted, but this is usually more expensive. Treatment of other weeds may permit gravity flow application, where the undiluted herbicide is poured slowly into the pond from a boat propelled across the surface in a regular pattern. Wind and water currents disperse and dilute the herbicide to the desired concentration.

Submersed (underwater) Weeds
Control of submersed weeds is not usually practical with surface spray applications. Gravity flow application is sometimes utilized but may be wasteful of herbicide. Herbicides are more effective in an aquatic situation if placed close to the root system or leaf area of the plant. Granule or pellet formulations are more frequently used to accomplish this. Another variation is the use of specialized equipment, used by commercial applicators, which places liquid herbicides in the "bottom acre-foot" of water near the site of uptake by the plant. The greater specific gravity of the herbicide holds the treatment in higher concentration near the plant for improved control.

Rates and Time of Application
If it is necessary to use aquatic herbicides in the management of a pond, it is best to apply them in the spring or early summer. Most aquatic herbicides can be effectively applied when water temperatures are above 55°F or when aquatic weeds show signs of new growth. Advantages of spring or early summer treatment are: 1. There is less of a chance of oxygen depletion and fish kills. 2. For some herbicides, a smaller amount of chemical is needed for control. 3. Many herbicides are more effective on plants in the early growth stages. Also, total plant mass is less, so less herbicide is required. 4. Early application of herbicides often facilitates later non-herbicide control measures such as fertilization.

Application rates should always be based upon label recommendations. However, if a pond has a heavy infestation of weeds it is wise to treat a fraction of the weeds in the pond at a time, waiting two or three weeks between applications. During the warm summer months, never treat the entire pond with a herbicide at one time, no matter how minor the weed infestation. Dead and decaying plants consume oxygen from the water. Treating a fraction (Figure 49) of the pond will allow the fish to escape to oxygenated water during the decay process and reduce the chances of a fish kill. When using herbicides, never wait until a pond has become choked by aquatic weeds. Instead, spot treat areas of weed growth early, before they become a problem.

Figure 49. Partial herbicide treatment.

Precautions and Warnings
Specific information concerning precautions and warnings is printed on the herbicide label. These precautions and warnings are listed to help ensure that no health hazard occurs because of their use. The following are applicable to any aquatic herbicide:

ATTENTION: Herbicide Precautions
1. Observe all directions, restrictions and precautions on herbicide labels. It is dangerous, wasteful and illegal to do otherwise.
2. Store all herbicides in original containers with labels intact and behind locked doors.

3. Use herbicides at correct dosage and intervals to avoid illegal residues or injury to animals.
4. Apply herbicides carefully to avoid drift.
5. Dispose of leftover herbicides and containers according to the directions on the label.

Topic 9 Submersed (underwater) Aquatic Weed Section Answers at the rear of Glossary

Fill-in-the-blank

1. Navigate and Aqua-Kleen is a granular butoxyethyl ester of 2,4-D and has been effective on Eurasian watermilfoil. 2,4-D compounds are systemic herbicides. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than_____.

2. Reward is a _____that has been effective on Eurasian watermilfoil and is very effective if mixed with a copper compound. It is a contact herbicide. Contact herbicides act quickly and kill all plants cells that they contact.

3. Renovate is a liquid triclopyr formulation that is effective on eurasian watermilfoil. It is a selective broadleaf, systemic herbicide. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides. An aquatically registered surfactant (see the label) will improve the effectiveness of_____.

4. Aquathol, Aquathol K, and Aquathol Super K are dipotassium salts of endothall and comes in both liquid and granular formulations. These endothall products have been effective on Eurasian watermilfoil and can be mixed with _____for additional effectiveness. Contact herbicides act quickly and kill all plant cells that they contact.

5. Hydrothol 191 is an alkylamine salt of endothall and comes in_____. It is a contact herbicide and has been effective on Eurasian watermilfoil. Contact herbicides act quickly and kill all plants cells that they contact. Hydrothol can be toxic to fish.

6. Sonar and Avast are fluridone compounds, come in both liquid and granular formulations, and have been effective on Eurasian watermilfoil. These are broad spectrum, systemic herbicides. Systemic herbicides are absorbed and move within the plant to the site of action. _____tend to act more slowly than contact herbicides.

7. Any aquatic plant identified as _____should be sent to a specialist for positive identification since hydrilla is such a serious threat to fresh water habitats. It is only through early identification and concentrated control methods that there is any hope of eliminating hydrilla. Fishermen or boaters in waters known to have hydrilla should make every effort not to accidentally transport hydrilla from one lake or pond to another.

Pond Water Chemistry

8. The water hardness also should be considered when using herbicides containing copper. Water hardness--Generally, water hardness is a measure of the _____in the water. In hard waters (above 50 parts per million hardness) it may be necessary to apply greater amounts of herbicide in order to achieve control. In soft waters (below 50 parts per million hardness) some herbicides are more toxic to fish and plants.

9. Herbicides which may be affected by water hardness have precautions listed on their labels. Water hardness is also an indicator of the lime requirement for the pond. See the section on Pond Fertilization. Many areas of the south have_____.

10. Pond owners should be familiar with the water hardness of their pond. Pond water hardness can be measured by most state Extension services or state game and fish departments. Copper--In soft water some_____, especially copper, can be toxic to fish. Some herbicides contain copper and should be used with caution in soft water ponds (less than 50 parts per million water hardness).

Topic 10 Aquatic Herbicides and Controls Section

Aquatic herbicides are chemicals specifically formulated for use in water to kill or control aquatic plants. Herbicides approved for aquatic use by the United States Environmental Protection Agency (**EPA**) have been reviewed and are considered compatible with the aquatic environment when used according to label directions. However, some individual states impose additional constraints on their use.

Aquatic herbicides are sprayed directly onto floating or emergent aquatic plants or are applied to the water in either a liquid or pellet form. **Systemic herbicides** are capable of killing the entire plant. **Contact herbicides** cause the parts of the plant in contact with the herbicide to die back, leaving the roots alive and able to regrow. **Non-selective**, broad spectrum herbicides will generally affect all plants that they come in contact with. **Selective** herbicides will affect only some plants (often dicots - broad leafed plants like Eur*asian watermilfoil (Myriophyllum spicatum) will be affected by selective herbicides, whereas monocots like Brazilian elodea (Egeria densa) may not be affected. Most aquatic plants are monocots.*

Endothall

What is Endothall and how is it used?

Endothall is an organic solid of white odorless crystals. Endothall is used as a defoliant for a wide range of crops and as a herbicide for both terrestrial and aquatic weeds. It is used as a desiccant on lucerne and on potato, for the defoliation of cotton, to control aquatic weeds and as an aquatic algaecide growth regulator. It has been used for: sugar beets, turf, hops sucker suppression; alfalfa, clover desiccants; potato vine killers.

The list of trade names given below may help you find out whether you are using this chemical at home or work.

Trade Names and Synonyms:
Accelerate
Aquathol
Des-i-cate
Endothall Turf Herbicide
Endothall Weed Killer
Herbicide 273
Hydrothol
Herbon Pennout
Hydout

Why is Endothall being Regulated?

In 1974, Congress passed the Safe Drinking Water Act. This law requires the EPA to determine safe levels of chemicals in drinking water which do or may cause health problems. These non-enforceable levels, based solely on possible health risks and exposure, are called Maximum Contaminant Level Goals.

What are the Health Effects?

Short-term: The EPA has found endothall to potentially cause the following health effects when people are exposed to it at levels above the MCL for relatively short periods of time: depressed breathing and heart rate. Long-term: Endothall has the potential to cause the following effects from a lifetime exposure at levels above the MCL: increase in size of some internal organs, particularly the stomach and intestine.

How much Endothall is produced and released to the environment?

The EPA estimated total domestic usage in 1982 to have been approximately 1.5 million lbs. Release of endothall to the environment is expected to occur primarily during its use as a pre-

emergence, post-emergence, turf and aquatic herbicide and harvest aid. Other sources of release include loss during manufacturing, formulation, packaging or disposal of this herbicide.

What happens to Endothall when it is released to the environment?
Endothall is expected to be quickly broken down by microbes in soil or water. It is also able to leach through soil into ground water; however, rapid degradation would limit the extent of leaching. Endothall is not likely to accumulate in aquatic life.

TRADE OR OTHER NAMES: Endothall is endothal in Great Britain. Trade names for the acid form of endothall (technical endothall) include Aquathol, Hydrothal-47 and Hydrothal-191. Trade names for the disodium salt of endothall (disodium endothall) include Accelerate, Des-I-Cate, Tri-endothal, Ripenthol, Hydrothol, and Niagrathol. The amine salt of endothall is also called Hydrothol.
REGULATORY STATUS: Endothall is a general use pesticide (GUP). When used as an aquatic herbicide, some water use restrictions may apply.
INTRODUCTION: Endothall is a member of the dicarboxylic acid chemical class. It is a selective contact herbicide. The potassium and amine salts of endothall are used as aquatic herbicides to control a variety of plants including plankton, pondweed, naiad, coontail, milfoil, elodea, and algaes in water bodies and rice fields. Endothall is also used to control annual grasses and broadleaf weeds in sugar beets, spinach and turf. It reduces sucker branch growth in hops. Endothall is a desiccant to aid the harvest of alfalfa, potatoes, clover, and cotton. The EPA has classified endothall as Toxicity Class II - moderately toxic. Products containing endothall bear the SIGNAL WORD: **WARNING**.
FORMULATION: It is available as granules or as a soluble concentrate.

TOXICOLOGICAL EFFECTS

- **Acute Toxicity:** Endothall is moderately toxic. The LD50 is the dose which kills half of the test animals treated. The oral LD50 for disodium endothall is 51 mg/kg for rats and 250 mg/kg for guinea pigs. The LD50 is 750 mg/kg for rats and 100 mg/kg for rabbits whose skin is exposed to disodium endothall. In humans, ingestion of 7 to 8g of disodium endothall causes repeated vomiting, hemorrhages, swelling in the lungs, and bleeding in the gastrointestinal tract. The LD50 for the amine salt of endothall is 206 mg/kg for rats and 143 mg/kg for rabbits whose skin is exposed to it. The oral LD50 for technical endothall is 38 mg/kg for rats. Endothall is very irritating to the eyes, skin, and mucous membranes.
- **Chronic Toxicity:** Information follows.
- **Reproductive Effects:** A three generation study was conducted by feeding male and female rats disodium endothall until they were 100 days old and then mating them. Three successive generations were maintained on the test diet for 100 days and then bred to produce the next generation. When examined at 21 days, rat pups in all three generations whose parents were given 15 mg/kg/day of disodium endothall had decreased body weights. No adverse reproductive effects were observed (NOEL) at 5 mg/kg/day.There were no observable signs of developmental toxicity at dose levels that were fatal to the females.
- **Teratogenic Effects:** Technical endothall was not teratogenic at the highest dose tested, 30 mg/kg/day.
- **Mutagenic Effects:** Studies show that technical endothall is not mutagenic in Salmonella bacteria nor in mouse cells. Aquathol K, a formulation of dipotassium endothall, is not mutagenic in fruit flies, mold, or human white blood cells. However, "commercial endothall," with no further description, was mutagenic in fruit flies.
- **Carcinogenic Effects:** No statistically significant numbers or types of tumors were observed in rats fed as much as 125 mg/kg/day of disodium endothall for two years. Thus, available evidence suggests that endothall does not cause cancer.
- **Organ Toxicity:** In male dogs, high doses of 20 mg/kg/day of disodium endothall for 6 weeks caused vomiting, diarrhea, damaged intestinal walls, and hemorrhages in the stomach. In rats, very high doses of 50 mg/kg/day of disodium endothall for four weeks caused liver and kidney damage.

- **Fate in Humans and Animals:** In rats dosed with technical endothall, over 95% of the dose was excreted within 48 hours. Within 72 hours after dosing, 99% of the dose was excreted. Approximately 90% of a dose of technical endothall is excreted in the feces and 7% in urine.

ECOLOGICAL EFFECTS

- **Effects on Birds:** No information is currently available.
- **Effects on Aquatic Organisms:** Endothall is toxic to some species of fish. Inorganic salts of endothall in aquatic formulations are safe to fish in 100-500 ppm concentrations. However, amine salts of endothall are more toxic to fish than the dipotassium endothall. Endothall has a low toxicity to crustaceans and a medium toxicity to aquatic insects. Long-term ingestion may cause severe damage to the digestive tract, liver and testes in fish.
- **Effects on Other Animals (Nontarget species):** Endothall is not toxic to bees.

ENVIRONMENTAL FATE

- **Breakdown of Chemical in Soil and Groundwater:** Endothall is highly mobile in soil, however rapid degradation limits the extent of leaching. Endothall disappears from soil in 7-21 days (1). The half-life (the amount of time needed for the concentration to be reduced by half) of endothall in soil is 4-5 days in clay soils and 9 days in soils with high organic content.
- **Breakdown of Chemical in Surface Water:** Endothall is rapidly degraded in water. Its half-life is 4 to 7 days for dipotassium endothall and about 7 days for technical endothall in surface water (312). It biodegrades more slowly when air is not present.
- **Breakdown of Chemical in Vegetation:** No information is currently available.

PHYSICAL PROPERTIES AND GUIDELINES

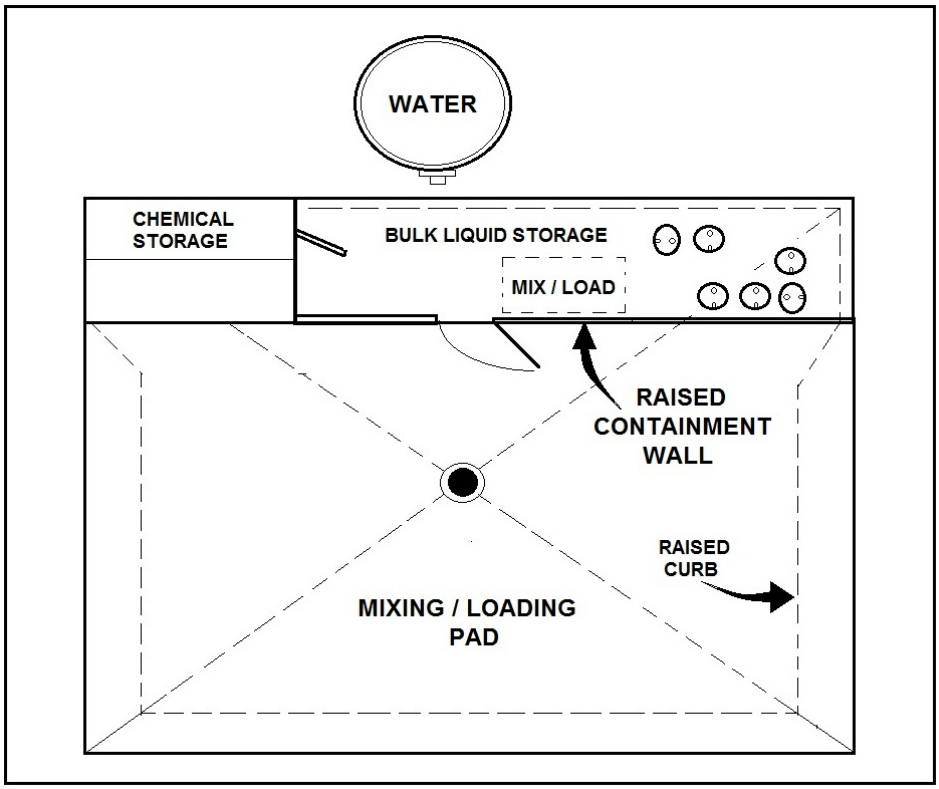
Physical Properties: All properties are for technical endothall unless otherwise noted.

- **Appearance:** Technical endothall is a colorless or white crystal which is stable to light, weak acidic media and weak alkaline media.
- **Chemical Name:** 3,6-endoxohexahydrophthalic acid (technical endothall),Disodium-3,6-endoxohexahydrophthalate (disodium endothall), 3,6-endoxohexahydrophthalic acid amine salt (amine salt of endothall)
- **CAS Number:** 145-73-3 (technical endothall), 129-67-9 (disodium salt of endothall), 6385-60-0 (amine salt of endothall)
- **Molecular Weight:** 186.2
- **Water Solubility:** 100 g/kg at 20 degrees C
- **Solubility in Other Solvents:** Soluble in benzene, isopropanol, acetone, dioxane, and methanol (disodium salt of endothall and technical endothall)
- **Melting Point:** 144 degrees C
- **Vapor Pressure:** 2.09 x 10-5 mPa (24.3 degrees C)
- **Partition Coefficient:** Not Available
- **Adsorption Coefficient:** -0.87

Exposure Guidelines: All guidelines are for technical endothall unless otherwise noted.

- **ADI:** 0.02 mg/kg
- **MCL**:0.1 mg/l
- **RfD:** 0.02 mg/kg/day
- **PEL:** Not Available
- **HA**: 0.8 mg/l
- **TLV**: Not Available

BASIC MANUFACTURER:
ELF Atochem, North America
Three Parkway, Room 619
Philadelphia, PA 19102 Telephone: 215-587-7885



PESTICIDE STORAGE/MIXING DIAGRAM

2017 Changes to EPA's Worker Protection Standard

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This course contains EPA's federal rule requirements. Please be aware that each state implements pesticide regulations that may be more stringent than EPA's regulations and these frequently are changed. Check with your state environmental/pesticide agency for more information.

Diquat Dibromide

Trade and Other Names: Trade names include Aquacide, Aquakill, Dextrone, Diquat, Reglone, Reglox, Reward, Tag, Torpedo, Vegetrole, and Weedtrine-D.

Regulatory Status: Diquat dibromide is a moderately toxic compound in EPA toxicity class II. It is a General Use Pesticide (GUP). Labels for products containing diquat dibromide must bear the Signal Word **WARNING**.

Chemical Class: desiccant

Introduction: Diquat dibromide is a nonselective, quick-acting herbicide and plant growth regulator, causing injury only to the parts of the plant to which it is applied. Diquat dibromide is referred to as a desiccant because it causes a leaf or an entire plant to dry out quickly. It is used to desiccate potato vines and seed crops, to control flowering of sugarcane, and for industrial and aquatic weed control. It is not residual; that is, it does not leave any trace of herbicide on or in plants, soil, or water.

Formulation: Not Available

Toxicological Effects:

- **Acute toxicity:** Diquat dibromide is moderately toxic via ingestion, with reported oral LD50 values of 120 mg/kg in rats, 233 mg/kg in mice, 188 mg/kg in rabbits, and 187 mg/kg in guinea pigs and dogs. Cows appear to be particularly sensitive to this herbicide, with an oral LD50 of 30 to 56 mg/kg. The acute dermal LD50 for diquat dibromide is approximately 400 to 500 mg/kg in rabbits, indicating moderate toxicity by this route as well. A single dose of diquat dibromide was not irritating to the skin of rabbits, but repeated dermal dosing did cause mild redness, thickening, and scabbing. Moderate to severe eye membrane irritation occurred when diquat dibromide was administered to rabbits. Ingestion of sufficient doses may cause severe irritation of the mouth, throat, esophagus, and stomach, followed by nausea, vomiting, diarrhea, severe dehydration, and alterations in body fluid balances, gastrointestinal discomfort, chest pain, diarrhea, kidney failure, and toxic liver damage. Skin absorption of high doses may cause symptoms similar to those that occur following ingestion. Very large doses of the herbicide can result in convulsions and tremors. Test animals (rats, mice, guinea pigs, rabbits, dogs, cows, and hens) given lethal doses of diquat dibromide showed a delayed pattern of illness, with onset approximately 24 hours following dosing, subsequent lethargy, pupil dilation, respiratory distress, weight loss, weakness and finally death over the course of 2 to 14 days after dosing. There have been reports of workers who have had softening and color changes in one or more fingernails after contact with concentrated diquat dibromide solutions. In some instances, the nail was shed, and did not grow in again. Several cases of severe eye injury in humans have occurred after accidental splashings. In each case, initial irritation was mild, but after several days, serious burns and sometimes scarring of the cornea developed. Direct or excessive inhalation of diquat dibromide spray mist or dust may result in oral or nasal irritation, nosebleeds, headache, sore throat, coughing, and symptoms similar to those from ingestion of diquat.
- **Chronic toxicity:** Chronic effects of diquat dibromide are similar to those of paraquat. Cataracts, a clouding of the eyes which interferes with light entering the eye, occurred in rats and dogs given 2.5 mg/kg/day and 5 mg/kg/day of diquat dibromide, respectively. Cataracts increased in proportion to the dose given in test animals (cats and dogs). Chronic exposure is necessary to produce these effects. Other effects on the eye (hemorrhage, retinal detachment) may occur at higher dosages. Rats fed dietary doses of 2.5 mg/kg/day over 2 years did not exhibit signs of toxicity other than reduced food intake and decreased growth. In another study using rats, oral doses of 4 mg/kg/day over 2 years produced no behavioral or other changes in general condition. At this dose level no evidence of change

in the kidneys, liver, or myocardium (heart muscle) were seen. This dosage (but not 2 mg/kg/day) caused changes in lung tissues. Repeated or prolonged dermal contact may cause inflammation of the skin, and, at high doses, systemic effects in other parts of the body. These may include damage to the kidneys. Chronic exposure may damage skin, which may increase the permeability of the skin to foreign compounds [88].

- **Reproductive effects:** Diquat dibromide generally did not reduce fertility when tested in experimental animals. Rats receiving 1.25 mg/kg/day decreased their food intake and showed slowed growth, but had unchanged reproduction. Fertility was reduced in male mice given diquat dibromide during different stages of sperm formation. Neither fertility nor reproduction was affected in a three-generation study in rats given dietary doses of 12.5 or 25 mg/kg/day of diquat dibromide, although some growth retardation was seen at the 25 mg/kg/day dose. Based on this evidence it is unlikely that diquat dibromide will cause reproductive effects in humans under normal circumstances.
- **Teratogenic effects:** Offspring of pregnant rats given a fatal injected dose of 14 mg/kg of diquat dibromide showed evidence of skeletal defects of the collar bone, as well as little or no ear bone formation upon examination. No deformities were found in the unborn offspring of pregnant rats that were injected intraperitoneally with 0.5 mg/kg/day of diquat daily during organogenesis, the stage of fetal development in which organs are formed. Growth retardation was seen in test animals given extremely high doses of diquat. While no actual teratogenesis occurred in rats given single abdominal injections during days 7 to 14 of pregnancy, many rats did not have normal weight gain and bone formation in the unborn was decreased. It is unlikely that diquat dibromide will cause teratogenic effects in humans under normal circumstances.
- **Mutagenic effects:** There is no evidence that diquat dibromide causes permanent changes in genetic material. For example, no mutagenic effects were seen in mice given oral doses of 10 mg/kg/day for 5 days.
- **Carcinogenic effects:** An 80-week feeding study showed that dietary doses of 15 mg/kg/day of diquat did not cause tumors in rats. Likewise, dietary levels of 36 mg/kg/day for 2 years did not induce tumors in rats. Based on the evidence, it appears that diquat dibromide is not carcinogenic.
- **Organ toxicity:** In animals, diquat dibromide may affect the gastrointestinal tract, eyes, kidneys or liver, and the lungs.
- **Fate in humans and animals:** Absorption of diquat dibromide from the gut into the bloodstream is low. Oral doses are mainly metabolized within the intestines, with metabolites being excreted in the feces. Rat studies showed only a small percentage of the applied oral dose (6%) was absorbed into the bloodstream and then excreted in the urine. Dermal, inhalation, or intravenous exposure results in little processing and rapid elimination in the urine. Following subcutaneous injection in rats, excretion of about 90% of the dose occurred in the urine on the first day and almost all of the remainder on the next day. Complete elimination of the herbicide was seen in urine and feces of rats within 4 days of administration of single oral doses of 5 to 10 mg/kg of diquat dibromide.

Ecological Effects:

- **Effects on birds:** Diquat dibromide ranges from slightly to moderately toxic to birds. The reported acute oral LD50 in young male mallards is 564 mg/kg. The oral LD50 for diquat dibromide is 200 to 400 mg/kg in hens. The 5-day dietary LC50 is about 1300 ppm in Japanese quail.
- **Effects on aquatic organisms:** Diquat dibromide is moderately to practically nontoxic to fish and aquatic invertebrates. The 8-hour LC50 for diquat dibromide is 12.3 mg/L in rainbow trout and 28.5 mg/L in Chinook salmon. The 96-hour LC50 is 16 mg/L in northern pike, 20.4 mg/L in fingerling trout, 245 mg/L in bluegill, 60 mg/L in yellow perch, and 170 mg/L in black bullhead. Research indicates that yellow perch suffer significant respiratory stress when herbicide concentrations in the water are similar to those normally present during aquatic vegetation control programs. There is little or no bioconcentration of diquat dibromide in fish.

- **Effects on other organisms:** Diquat dibromide is not toxic to honey bees. Since diquat dibromide is a nonselective herbicide, it may present a danger to non-target plant species. Cows are particularly sensitive to the toxic effects of this material.

Environmental Fate:

- **Breakdown in soil and groundwater:** Diquat dibromide is highly persistent, with reported field half-lives of greater than 1000 days. It is very well sorbed by soil organic matter and clay. Although it is water soluble, its capacity for strong adsorption to soil particles suggest that it will not easily leach through the soil, be taken up by plants or soil microbes, or broken down by sunlight (photochemical degradation). Field and laboratory tests show that diquat usually remains in the top inch of soil for long periods of time after it is applied.
- **Breakdown in water:** Studies on the erosion of diquat-treated soils near bodies of water indicate that diquat dibromide stays bound to soil particles, remaining biologically inactive in surface waters, such as lakes, rivers, and ponds. When diquat dibromide is applied to open water, it disappears rapidly because it binds to suspended particles in the water. Diquat dibromide's half-life is less than 48 hours in the water column, and may be on the order of 160 days in sediments due to its low bioavailability. Microbial degradation and sunlight play roles in the breakdown of the compound. At 22 days after a weed infested artificial lake was treated, only 1% of the applied diquat dibromide remained in the water and 19% was adsorbed to sediments.
- **Breakdown in vegetation:** Diquat dibromide is rapidly absorbed into the leaves of plants, but usually kills the plant tissues necessary for translocation too quickly to allow movement to other parts of the plant. The herbicide interferes with cell respiration, the process by which plants produce energy. Diquat dibromide is broken down on the plant surface by photochemical degradation. It is rapidly absorbed by aquatic weeds from the surrounding water and concentrated in the plant tissue. Thus, even low concentrations of the herbicide can control aquatic weeds.

Physical Properties:

- **Appearance:** Technical diquat dibromide, which is greater than 95% pure, forms white to yellow crystals.
- **Chemical Name:** 1,1'-ethylene-2,2'-bipyridyldiylium dibromide salt
- **CAS Number:** 85-00-7
- **Molecular Weight:** 344.06
- **Water Solubility:** 700,000 mg/L @ 20 C; v.s.
- **Solubility in Other Solvents:** i.s. in nonpolar solvents such as chloroform, diethyl ether, and petroleum ether [1]; s.s in alcohol and hydroxylic solvents
- **Melting Point:** Decomposes above 300 C
- **Vapor Pressure:** Negligible @ 20 C
- **Partition Coefficient:** -4.6021
- **Adsorption Coefficient:** 1,000,000 (estimated)

Exposure Guidelines:

- **ADI:** 0.002 mg/kg/day
- **MCL**: 0.02 mg/L
- **RfD:** 0.0022 mg/kg/day
- **PEL:** Not Available
- **HA**: Not Available
- **TLV**: 0.1 mg/m3 (8-hour) (respirable fraction)

Basic Manufacturer:
Zeneca Ag Products
1800 Concord Pike
Wilmington, DE 19897

- **Phone:** 800-759-4500
- **Emergency:** 800-759-2500

DISCLAIMER: The information in this profile does not in any way replace or supersede the information on the pesticide product labeling or other regulatory requirements. Please refer to the pesticide product labeling.

This course contains EPA's federal rule requirements. Please be aware that each state implements pesticide regulations that may be more stringent than EPA's regulations and these frequently are changed. Check with your state environmental/pesticide agency for more information.

Glyphosate

Trade and Other Names: Trade names for products containing glyphosate include Gallup, Landmaster, Pondmaster, Ranger, Roundup, Rodeo, and Touchdown. It may be used in formulations with other herbicides.

Regulatory Status: Glyphosate acid and its salts are moderately toxic compounds in EPA toxicity class II. Labels for products containing these compounds must bear the Signal Word **WARNING**.

Glyphosate is a General Use Pesticide (GUP).

Chemical Class: Not Available

Introduction: Glyphosate is a broad-spectrum, nonselective systemic herbicide used for control of annual and perennial plants including grasses, sedges, broad-leaved weeds, and woody plants. It can be used on non-cropland as well as on a great variety of crops. Glyphosate itself is an acid, but it is commonly used in salt form, most commonly the isopropylamine salt. It may also be available in acidic or trimethylsulfonium salt forms. It is generally distributed as water-soluble concentrates and powders. The information presented here refers to the technical grade of the acid form of glyphosate, unless otherwise noted.

Formulation: Glyphosate itself is an acid, but it is commonly used in salt form, most commonly the isopropylamine salt. It may also be available in acidic or trimethylsulfonium salt forms. It is generally distributed as water-soluble concentrates and powders.

Toxicological Effects:

- **Acute toxicity:** Glyphosate is practically nontoxic by ingestion, with a reported acute oral LD50 of 5600 mg/kg in the rat. The toxicities of the technical acid (glyphosate) and the formulated product (Roundup) are nearly the same. The oral LD50 for the trimethylsulfonium salt is reported to be approximately 750 mg/kg in rats, which indicates moderate toxicity. Formulations may show moderate toxicity as well (LD50 values between 1000 mg/kg and 5000 mg/kg). Oral LD50 values for glyphosate are greater than 10,000 mg/kg in mice, rabbits, and goats. It is practically nontoxic by skin exposure, with reported dermal LD50 values of greater than 5000 mg/kg for the acid and isopropylamine salt. The trimethylsulfonium salt has a reported dermal LD50 of greater than 2000 mg/kg. It is reportedly not irritating to the skin of rabbits, and does not induce skin sensitization in guinea pigs. It does cause eye irritation in rabbits. Some formulations may cause much more extreme irritation of the skin or eyes. In a number of human volunteers, patch tests produced no visible skin changes or sensitization. The reported 4-hour rat inhalation LC50 values for the technical acid and salts were 5 to 12 mg/L, indicating moderate toxicity via this route. Some formulations may show high acute inhalation toxicity. While it does contain a phosphatyl functional group, it is not structurally similar to organophosphate pesticides which contain organophosphate esters, and it does not significantly inhibit cholinesterase activity.
- **Chronic toxicity:** Studies of glyphosate lasting up to 2 years, have been conducted with rats, dogs, mice, and rabbits, and with few exceptions no effects were observed. For example, in a chronic feeding study with rats, no toxic effects were observed in rats given doses as high as 400 mg/kg/day. Also, no toxic effects were observed in a chronic feeding study with dogs fed up to 500 mg/kg/day, the highest dose tested.
- **Reproductive effects:** Laboratory studies show that glyphosate produces reproductive changes in test animals very rarely and then only at very high doses (over 150 mg/kg/day). It is unlikely that the compound would produce reproductive effects in humans.
- **Teratogenic effects:** In a teratology study with rabbits, no developmental toxicity was observed in the fetuses at the highest dose tested (350 mg/kg/day). Rats given doses up to 175 mg/kg/day on days 6 to 19 of pregnancy had offspring with no teratogenic effects,

but other toxic effects were observed in both the mothers and the fetuses. No toxic effects to the fetuses occurred at 50 mg/kg/day. Glyphosate does not appear to be teratogenic.

- **Mutagenic effects:** Glyphosate mutagenicity and genotoxicity assays have been negative. These included the Ames test, other bacterial assays, and the Chinese Hamster Ovary (CHO) cell culture, rat bone marrow cell culture, and mouse dominant lethal assays. It appears that glyphosate is not mutagenic.
- **Carcinogenic effects:** Rats given oral doses of up to 400 mg/kg/day did not show any signs of cancer, nor did dogs given oral doses of up to 500 mg/kg/day or mice fed glyphosate at doses of up to 4500 mg/kg/day. It appears that glyphosate is not carcinogenic.
- **Organ toxicity:** Some microscopic liver and kidney changes, but no observable differences in function or toxic effects, have been seen after lifetime administration of glyphosate to test animals.
- **Fate in humans and animals:** Glyphosate is poorly absorbed from the digestive tract and is largely excreted unchanged by mammals. At 10 days after treatment, there were only minute amounts in the tissues of rats fed glyphosate for 3 weeks]. Cows, chickens, and pigs fed small amounts of glyphosate had undetectable levels (less than 0.05 ppm) in muscle tissue and fat. Levels in milk and eggs were also undetectable (less than 0.025 ppm). Glyphosate has no significant potential to accumulate in animal tissue.

Ecological Effects:

- **Effects on birds:** Glyphosate is slightly toxic to wild birds. The dietary LC50 in both mallards and bobwhite quail is greater than 4500 ppm.
- **Effects on aquatic organisms:** Technical glyphosate acid is practically nontoxic to fish and may be slightly toxic to aquatic invertebrates. The 96-hour LC50 is 120 mg/L in bluegill sunfish, 168 mg/L in harlequin, and 86 mg/L in rainbow trout. The reported 96-hour LC50 values for other aquatic species include greater than 10 mg/L in Atlantic oysters, 934 mg/L in fiddler crab, and 281 mg/L in shrimp [58]. The 48-hour LC50 for glyphosate in Daphnia (water flea), an important food source for freshwater fish, is 780 mg/L. Some formulations may be more toxic to fish and aquatic species due to differences in toxicity between the salts and the parent acid or to surfactants used in the formulation. There is a very low potential for the compound to build up in the tissues of aquatic invertebrates or other aquatic organisms.
- **Effects on other organisms:** Glyphosate is nontoxic to honeybees. Its oral and dermal LD50 is greater than 0.1 mg/ bee. The reported contact LC50 values for earthworms in soil are greater than 5000 ppm for both the glyphosate trimethylsulfonium salt and Roundup.

Environmental Fate:

- **Breakdown in soil and groundwater:** Glyphosate is moderately persistent in soil, with an estimated average half-life of 47 days. Reported field half-lives range from 1 to 174 days. It is strongly adsorbed to most soils, even those with lower organic and clay content. Thus, even though it is highly soluble in water, field and laboratory studies show it does not leach appreciably, and has low potential for runoff (except as adsorbed to colloidal matter). One estimate indicated that less than 2% of the applied chemical is lost to runoff. Microbes are primarily responsible for the breakdown of the product, and volatilization or photodegradation losses will be negligible.
- **Breakdown in water:** In water, glyphosate is strongly adsorbed to suspended organic and mineral matter and is broken down primarily by microorganisms. Its half-life in pond water ranges from 12 days to 10 weeks.
- **Breakdown in vegetation:** Glyphosate may be translocated throughout the plant, including to the roots. It is extensively metabolized by some plants, while remaining intact in others.

Physical Properties:

- **Appearance:** Glyphosate is a colorless crystal at room temperature.
- **Chemical Name:** N-(phosphonomethyl) glycine
- **CAS Number:** 1071-83-6
- **Molecular Weight:** 169.08
- **Water Solubility:** 12,000 mg/L @ 25 C
- **Solubility in Other Solvents:** i.s. in common organics (e.g., acetone, ethanol, and xylene)
- **Melting Point:** 200 C
- **Vapor Pressure:** negligible
- **Partition Coefficient:** -3.2218 - -2.7696
- **Adsorption Coefficient:** 24,000 (estimated)

Exposure Guidelines:

- **ADI:** 0.3 mg/kg/day
- **MCL**: Not Available
- **RfD:** 0.1 mg/kg/day
- **PEL:** Not Available
- **HA**: 0.7 mg/L (lifetime)
- **TLV**: Not Available

Basic Manufacturer:
Monsanto Company
800 N. Lindbergh Blvd.
St. Louis, MO 63167

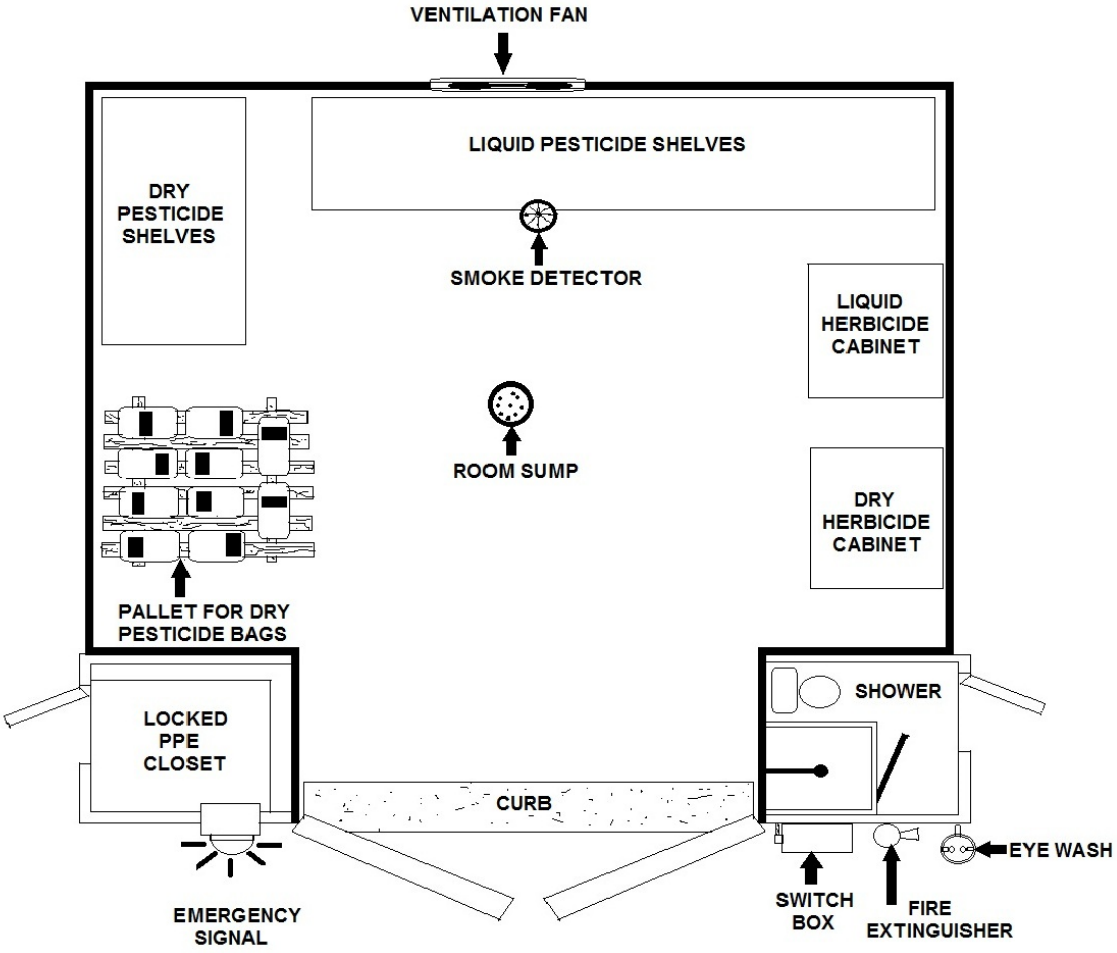
- **Phone:** 314-694-6640
- **Emergency:** 314-694-4000

DISCLAIMER: The information in this profile does not in any way replace or supersede the information on the pesticide product labeling or other regulatory requirements. Please refer to the pesticide product labeling.

2017 Changes to EPA's Worker Protection Standard

In late 2015 the Environmental Protection Agency issued the long awaited revision to the Worker Protection Standard (WPS). This law it is now technically active and it will be enforced. Please keep in mind that the WPS covers both restricted use AND general use pesticides. This course is not for worker and/or handler training. Always follow the label and your State Pesticide Agency rules.

This course contains EPA's federal rule requirements. Please be aware that each state implements pesticide regulations that may be more stringent than EPA's regulations and these frequently are changed. Check with your state environmental/pesticide agency for more information.



PESTICIDE STORAGE BUILDING DIAGRAM EXAMPLE

2,4-D

Trade and Other Names: 2,4-D is used in many commercial products. Commercial names for products containing 2,4-D include Aqua-Kleen, Barrage, Lawn-Keep, Malerbane, Planotox, Plantgard, Savage, Salvo, Weedone, and Weedtrine-II.

Regulatory Status: 2,4-D is a General Use Pesticide (GUP) in the U.S. The diethylamine salt is toxicity class III- slightly toxic orally, but toxicity class I- highly toxic by eye exposure. It bears the Signal Word **DANGER - POISON** because 2,4-D has produced serious eye and skin irritation among agricultural workers.

Chemical Class: phenoxy compound

Introduction: There are many forms or derivatives of 2,4-D including esters, amines, and salts. Unless otherwise specified, this document will refer to the acid form of 2,4-D. 2,4-D, a chlorinated phenoxy compound, functions as a systemic herbicide and is used to control many types of broadleaf weeds. It is used in cultivated agriculture, in pasture and rangeland applications, forest management, home, garden, and to control aquatic vegetation. It may be found in emulsion form, in aqueous solutions (salts), and as a dry compound.

The product Agent Orange, used extensively throughout Vietnam, was about 50% 2,4-D. However, the controversies associated with the use of Agent Orange were associated with a contaminant (dioxin) in the 2,4,5-T component of the defoliant.

Formulation: It may be found in emulsion form, in aqueous solutions (salts), and as a dry compound.
Toxicological Effects:

- **Acute toxicity:** The acid form is of slight to moderate toxicity. The oral LD50 of 2,4-D ranges from 375 to 666 mg/kg in the rat, 370 mg/kg in mice, and from less than 320 to 1000 mg/kg in guinea pigs. The dermal LD50 values are 1500 mg/kg in rats and 1400 mg/kg in rabbits, respectively. In humans, prolonged breathing of 2,4-D causes coughing, burning, dizziness, and temporary loss of muscle coordination. Other symptoms of poisoning can be fatigue and weakness with possible nausea. On rare occasions following high levels of exposure, there can be inflammation of the nerve endings with muscular effects.
- **Chronic toxicity:** Rats given high amounts, 50 mg/kg/day, of 2,4-D in the diet for 2 years showed no adverse effects. Dogs fed lower amounts in their food for 2 years died, probably because dogs do not excrete organic acids efficiently. A human given a total of 16.3 g in 32 days therapeutically, lapsed into a stupor and showed signs of incoordination, weak reflexes, and loss of bladder control.
- **Reproductive effects:** High levels of 2,4-D (about 50 mg/kg/day) administered orally to pregnant rats did not cause any adverse effects on birth weights or litter size. Higher doses (188 mg/kg/day) resulted in fetuses with abdominal cavity bleeding and increased mortality. DNA synthesis in the testes was significantly inhibited when mice were fed large amounts (200 mg/kg/day) of 2,4-D. The evidence suggests that if 2,4-D causes reproductive effects in animals, this only occurs at very high doses. Thus reproductive problems associated with 2,4-D are unlikely in humans under normal circumstances.
- **Teratogenic effects:** 2,4-D may cause birth defects at high doses. Rats fed 150 mg/kg/day on days 6 to 15 of pregnancy had offspring with increased skeletal abnormalities, such as delayed bone development and wavy ribs. This suggests that 2,4-D exposure is unlikely to be teratogenic in humans at expected exposure levels.
- **Mutagenic effects:** 2,4-D has been very extensively tested and was found to be non-mutagenic in most systems. 2,4-D did not damage DNA in human lung cells. However, in one study, significant effects occurred in chromosomes in cultured human cells at low

exposure levels [26]. The data suggest that 2,4-D is not mutagenic or has low mutagenic potential.

- **Carcinogenic effects:** 2,4-D fed to rats for 2 years caused an increase in malignant tumors. Female mice given a single injection of 2,4-D developed cancer (reticulum-cell sarcomas). Another study in rodents shows a low incidence of brain tumors at moderate exposure levels (45 mg/kg/day) over a lifetime. However, a number of questions have been raised about the validity of this evidence and thus about the carcinogenic potential of 2,4-D. In humans, a variety of studies give conflicting results. Several studies suggest an association of 2,4-D exposure with cancer. An increased occurrence of non-Hodgkin's lymphoma was found among a Kansas and Nebraska farm population associated with the spraying of 2,4-D. Other studies done in New Zealand, Washington, New York, Australia, and on Vietnam veterans from the U.S. were all negative. There remains considerable controversy about the methods used in the various studies and their results. Thus, the carcinogenic status of 2,4-D is not clear.
- **Organ toxicity:** Most symptoms of 2,4-D exposure disappear within a few days, but there is a report of liver dysfunction from long-term exposure.
- **Fate in humans and animals:** The absorption of 2,4-D is almost complete in mammals after ingestion and nearly all of the dose is excreted in the urine. The compound is readily absorbed through the skin and lungs. Men given 5 mg/kg excreted about 82% of the dose as unchanged 2,4-D. The half-life is between 10 and 20 hours in living organisms. There is no evidence that 2,4-D accumulates to significant level in mammals or in other organisms. Between 6 and 8 hours after doses of 1 mg/kg, peak concentrations of 2,4-D were found in the blood, liver, kidney, lungs, and spleen of rats. There were lower levels in muscle and brain. After 24 hours, there were no detectable tissue residues. Only traces of the compound have been found in the milk of lactating animals for 6 days following exposure. 2,4-D passes through the placenta in pigs and rats. In rats, about 20% was detected in the uterus, placenta, fetus, and amniotic fluid. Chickens given moderate amounts of 2,4-D in drinking water from birth to maturity had very low levels of the compound in eggs.

Ecological Effects:

- **Effects on birds:** 2,4-D is slightly toxic to wildfowl and slightly to moderately toxic to birds. The LD50 is 1000 mg/kg in mallards, 272 mg/kg in pheasants, and 668 mg/kg in quail and pigeons.
- **Effects on aquatic organisms:** Some formulations of 2,4-D are highly toxic to fish while others are less so. For example, the LC50 ranges between 1.0 and 100 mg/L in cutthroat trout, depending on the formulation used. Channel catfish had less than 10% mortality when exposed to 10 mg/L for 48 hours. Green sunfish, when exposed to 110 mg/L for 41 hours, showed no effect on swimming response. Limited studies indicate a half-life of less than 2 days in fish and oysters. Concentrations of 10 mg/L for 85 days did not adversely affect the survival of adult Dungeness crabs. For immature crabs, the 96-hour LC50 is greater than 10 mg/L, indicating that 2,4-D is only slightly toxic. Brown shrimp showed a small increase in mortality at exposures of 2 mg/L for 48 hours.
- **Effects on other organisms:** Moderate doses of 2,4-D severely impaired honeybees brood production. At lower levels of exposure, exposed bees lived significantly longer than the controls. The honeybee LD50 is 0.0115 mg/bee.

Environmental Fate:

- **Breakdown in soil and groundwater:** 2,4-D has low soil persistence. The half-life in soil is less than 7 days. Soil microbes are primarily responsible for its disappearance [20]. Despite its short half-life in soil and in aquatic environments, the compound has been detected in groundwater supplies in at least five States and in Canada. Very low concentrations have also been detected in surface waters throughout the U.S.

- **Breakdown in water:** In aquatic environments, microorganisms readily degrade 2,4-D. Rates of breakdown increase with increased nutrients, sediment load, and dissolved organic carbon. Under oxygenated conditions the half-life is 1 week to several weeks.
- **Breakdown in vegetation:** 2,4-D interferes with normal plant growth processes. Uptake of the compound is through leaves, stems, and roots. Breakdown in plants is by a variety of biological and chemical pathways. 2,4-D is toxic to most broad leaf crops, especially cotton, tomatoes, beets, and fruit trees.

Physical Properties:

- **Appearance:** 2,4-D is a white powder.
- **Chemical Name:** (2,4-dichlorophenoxy)acetic acid
- **CAS Number:** 94-75-7
- **Molecular Weight:** 221.04
- **Water Solubility:** 900 mg/L @ 25 C (acid)
- **Solubility in Other Solvents:** ethanol v.s.; diethyl ether v.s.; toluene s.; xylene s
- **Melting Point:** 140.5 C
- **Vapor Pressure:** 0.02 mPa @ 25 C (acid)
- **Partition Coefficient:** 2.81
- **Adsorption Coefficient:** 20 (acid)

Exposure Guidelines:

- **ADI:** 0.3 mg/kg/day
- **MCL**: 0.07 mg/L
- **RfD:** 0.01 mg/kg/day
- **PEL:** 10 mg/m3 (8-hour)
- **HA**: Not Available
- **TLV**: Not Available

Basic Manufacturer:
Rhone-Poulenc Ag. Co.
P.O. Box 12014
2 T.W. Alexander Dr.
Research Triangle Park, NC 27709

- **Phone:** 919-549-2000
- **Emergency:** 800-334-7577

DISCLAIMER: The information in this profile does not in any way replace or supersede the information on the pesticide product labeling or other regulatory requirements. Please refer to the pesticide product labeling.

Triclopyr - (Trade name Renovate3®).

There are two formulations of triclopyr. It is the TEA formation of triclopyr that is registered for use in aquatic or riparian environments. Triclopyr, applied as a liquid, is a relatively fast-acting, systemic, selective herbicide used for the control of Eurasian watermilfoil and other broad-leaved species such as purple loosestrife. Triclopyr can be effective for spot treatment of Eurasian watermilfoil and is relatively selective to Eurasian watermilfoil when used at the labeled rate.

Many native aquatic species are unaffected by triclopyr. Triclopyr is very useful for purple loosestrife control since native grasses and sedges are unaffected by this herbicide. When applied directly to water, Ecology has imposed a 12-hour swimming restriction to minimize eye irritation.

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Imazapyr (Trade name Habitat®).

This systemic broad spectrum herbicide, applied as a liquid, is used to control emergent plants like spartina, reed canarygrass, and phragmites and floating-leaved plants like water lilies. Imazapyr does not work on underwater plants such as Eurasian watermilfoil. Although imazapyr is a broad spectrum, non-selective herbicide, a good applicator can somewhat selectively remove targeted plants by focusing the spray only on the plants to be removed.

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Fluridone

Trade names for fluridone products include: Sonar® and Avast!®). Fluridone is a slow-acting systemic herbicide used to control Eurasian watermilfoil and other underwater plants. It may be applied as a pellet or as a liquid. Fluridone can show good control of submersed plants where there is little water movement and an extended time for the treatment. Its use is most applicable to whole-lake or isolated bay treatments where dilution can be minimized. It is not effective for spot treatments of areas less than five acres. It is slow-acting and may take six to twelve weeks before the dying plants fall to the sediment and decompose.

When used to manage Eurasian watermilfoil, fluridone is applied several times during the spring/summer to maintain a low, but consistent, concentration in the water. Although fluridone is considered to be a broad spectrum herbicide, when used at very low concentrations, it can be used to selectively remove Eurasian watermilfoil. Some native aquatic plants, especially pondweeds, are minimally affected by low concentrations of fluridone.

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Procedures for Calculating Lake Volumes for Proposed Fall Fluridone Treatments

This is the standard procedure used to calculate the volume of water within a lake and to determine the appropriate application amount of aqueous solution of fluridone (Sonar A.S.® and AVAST!™). The goal of this procedure is to achieve rapid and uniform distribution of a given fluridone concentration by treating water within the 0-5 foot depth contour and those areas with depth greater than 5 feet separately with different amounts of fluridone. This procedure determines the amount of product necessary to treat an entire lake at a given concentration. An example is presented for calculating a concentration of 5 ppb fluridone applied to a lake that has a surface area (0-foot) of 239 acres, an area of 189 acres at the 5-foot depth contour, and 71 acres at the 10-foot depth contour. A1, A2, and A3 represent the areas for those depth contours, respectively.

Volume Calculations

STEPS

1. Determine the surface acres of the 0-, 5-, and 10-foot depth contours.
Example: 0-, 5-, and 10-foot depth contours are 239, 189, and 71 acres, respectively.
2. Use the following formula for calculating the volume of a frustum for the lake between the surface (0-foot) and 5-foot depth contours.

V (acre-feet) = h/3 (A1 + A2 + [sq. rt. (A1 x A2)])

Where: V = volume, h = height of the water column in feet, A1 = area of the lake surface in acres, and A2 = area of the 5-foot contour in acres.
Example: The volume of water to the 5-foot depth contour = 5/3 (239 + 189 + [sq. rt. (239 x 189)]) = 1069 acre-feet
3. Multiply the area of the 5-foot contour by 5 feet.

Example: 189 acres x 5 feet = 945 acre-feet
4. Subtract Step 3 from Step 2 to calculate the volume of water in the 0- to 5-foot "donut" area.
Example: 1069 acre-feet – 945 acre-feet = 124 acre-feet
5. Multiply Step 4 by 2.72 (pounds of the active ingredient fluridone in a one part per million solution in an acre-foot of water). Then multiply that value by the target concentration in parts per **million,** not in parts per billion. One quart of product (Sonar A.S.® or AVAST!™) contains one pound of the active ingredient fluridone.
Example: At 5 ppb; 124 acre-feet x 2.72 x 0.005 = 1.7 pounds of fluridone or 1.7 quarts of product (Sonar A.S.® or AVAST!™).
6. Enter the 5- and 10-foot depth contour areas into the volume formula for a frustum as presented in Step 2 to find the volume of water between the 5- to10-foot contours.
Example: V = 5/3 (189 + 71 + [sq. rt. of (189 x 71)]) = 628 acre-feet
Repeat Step 6 to determine the volumes between the various depth contours.
Example: 10-20 feet, 20-30 feet, etc.
7. Add the values calculated for Steps 3 and Step 6 (for each depth contour volume) to determine the volume of the "donut hole" area from the 5-foot depth contour to the lake bottom.
Example: (628 acre-feet + 945 acre-feet + (10-20 foot depth in acre-feet) + (20-30 foot depth in acre-feet) etc. = 1573 acre feet
8. Multiply Step 7 by 2.72 (pounds of the active ingredient fluridone in a one part per million solution in an acre-foot of water). Then multiply that value by the target concentration in parts per **million,** not in parts per billion. One quart of product (Sonar A.S.® or AVAST!™) contains one pound of the active ingredient fluridone. This quantity of product is then distributed in the greater than 5 foot “donut hole” area.
Example: At 5 ppb; 1573 acre-feet x 2.72 x 0.005 = 21.4 pounds of fluridone or 21.4 quarts of product (Sonar A.S.® or AVAST!™).
9. Add the values in Steps 5 and 8 to obtain the total amount of product necessary to treat the lake to a depth of 10 feet at a given concentration.
Example: At 5 ppb; 1.7 quarts + 21.4 quarts = 23.1 quarts of product.

Product Distribution
Distribute the product in the 0- to 5-foot depth contour “donut” area by zigzagging the boat within the water that is 0 to 5 feet deep as evenly as possible. Distribute the product in the water deeper than 5 feet (the “donut hole”) in a crisscross pattern.

Distributions are best when each of these areas are broken into smaller sectional areas and just the amount of product used for that subsection is placed in the mixing tank. However, this requires additional calculations for the respective subsections.

This course contains EPA’s federal rule requirements. Please be aware that each state implements pesticide regulations that may be more stringent than EPA’s regulations and these frequently are changed. Check with your state environmental/pesticide agency for more information.

Copper-Resistant Algae

One form of filamentous algae, Pithophora, can be especially troublesome because it is resistant to normal applications of copper compounds. Although it is not widespread, scattered reports of Pithophora in ponds are received every year. If, after a normal treatment with copper sulfate, there is algae remaining that does not appear to be affected, it may be Pithophora.

Pithophora is extremely difficult to control. Its unique cell wall structure and the tight clumping of filaments inhibit the penetration by copper. Additionally, large numbers of resilient spore-like bodies, called akinetes, germinate and provide a continuous source of new plants. Partial, short term control can usually be achieved with either of the following herbicide mixtures:

	Ratio	Application Rate of Mixture
Cutrine Plus Liquid and Diquat/Reward	1:1	2 gallons per acre-foot
Cutrine Plus Liquid and Hydrothol 191 Liquid	2:1	1 gallon per acre-foot

Additionally, Cide-Kick, a nonionic spray adjuvant, should be added to the mixture at the rate of 1-2 gallons per surface-acre. This material acts as a cell wall penetrant to increase the effectiveness of the herbicides.

Special Precautions
Fish are extremely sensitive to Hydrothol 191. To reduce the hazard of a fish kill, start application at the shoreline and move outward so that fish can escape from treated areas. Select another product if fish toxicity is a concern.

Copper sulfate is corrosive to galvanized containers. Therefore, the solution should be mixed in wooden, earthenware, plastic, stainless steel or copper-lined containers. If a sprayer is not available, you may broadcast the solution with a plastic watering can or bucket and dipper.

If the algae is so abundant that it covers more than half of the total pond surface, a complete treatment may result in an oxygen depletion and fish kill. This hazard is greatest during very hot, overcast weather. When these conditions exist, treat only half the pond and wait 10-14 days before treating the other half.

Copper compounds applied at the recommended rates are lethal to fish eggs and some species of newly hatched fish. These materials should not be applied during spawning periods, unless it is desirable to destroy the eggs and the new hatch. Bass will begin to construct shallow depressions in the pond bottom when the water reaches 60°F. Eggs are deposited by the female and guarded by the male for 3-14 days.

Within a couple of weeks after the bass have spawned and when the water temperature reaches 70°F, bluegill and redear sunfish will be seen building nests in the shallow areas. As with the bass, the male guards the nest after the eggs have been deposited. These eggs will hatch in a few days. Bass will only spawn once in the spring, but forage fish (bluegill, redear sunfish and minnows) will spawn throughout much of the summer and some individuals may spawn several times in a single season. To avoid the application of copper compounds during the spawning season, monitor the water temperature and look for active nests in the shallow areas of the pond.

Detailed Algaecide Section

Copper Sulfate

Most species of algae can be controlled with very low concentrations of copper sulfate. It is available in crystalline nuggets the size of rock salt or as a finely ground "snow" grade (Figure 1). The recommended treatment rate is 2.7 pounds per acre-foot of water. Acre-feet is a volume measurement of the pond. It is determined by multiplying average depth (feet) X surface area (acres). For more information on calculating measurements, see the prior section in this book. When uniformly applied, this will result in a 1 part per million (ppm) concentration throughout the volume of the pond. For very hard water (more than 12 grains or 200 parts per million of hardness), this rate should be doubled.

Figure 1. Copper sulfate is available as nuggets (left) or as finely ground crystals.

The method of application will determine what size of copper sulfate crystals to purchase. The important principle to keep in mind is that actual contact of the copper sulfate with the algae is necessary in order to achieve satisfactory control. For best results, dissolve copper sulfate in water and spray it directly on floating algal mats or on the water surface above submerged algae.

Finely ground, "snow grade" copper sulfate is best for this method, as it dissolves easier. Mix the desired amount of copper sulfate with enough water to cover the area to be treated, and apply with a sprayer or bucket and dipper. Because copper is corrosive to galvanized metal, application equipment and mixing containers should be made of plastic or stainless steel. In large ponds and when spray equipment is not available, it may be easier to treat with copper sulfate by placing the larger crystals of this chemical in a burlap bag and towing the bag through the water until all the crystals have been dissolved in the area to be treated.

One application of copper sulfate is unlikely to provide season-long control. Re-treatment may be necessary at 3-4 week intervals. There are no water-use restrictions associated with the use of copper sulfate. When applied at the proper rate, the water may be used immediately for swimming, drinking, fishing, irrigation and livestock. However, since copper sulfate has a metallic odor, pond owners may want to suspend drinking, swimming and livestock watering uses for 12 hours.

A 25% copper compound has been used for years as an algaecide. This product is effective against all forms of algae including: filamentous, planktonic, and branched algae. The crystal form is most effective on bottom mats while the fine crystal may be easily spread or dissolved in water. Copper sulfate is less effective in hard water than chelated copper products. This product is corrosive to metal equipment and toxic to fish in soft water.

Normal application rate is 2.7 pounds per acre foot of water treated. Effective for control of swimmers itch with special application methods. There are no restrictions on water usage following application.

Copper Chelate

Copper is also available in a chelated, or buffered, formulation, which is manufactured as a liquid or granule. This provides some advantages during application. The liquid form needs only to be mixed with water and sprayed out over the pond surface; there are no crystals to dissolve. The granular formulation consists of a clay granule impregnated with copper chelate.

As the granule breaks down, the copper is released into the water. This formulation is especially useful when spot treatment is desirable. Granules are best suited for application early in the growing season because of the time required (2-3 weeks) for them to dissolve and release the chemical. There are no water-use restrictions associated with either formulation of copper chelate.

Captain

A 9% chelated copper algaecide for use in potable water reservoirs; farm, fish, and fire ponds; lakes; and fish hatcheries. Captain provides effective control of planktonic algae, including: Anabaena, Aphanizomenon, and Microcystis; filamentous algae, including; Spirogyra, Cladophora, Phizoclonium, and Hydrodictyon; and branched algae, including: Chara and Nitella. Application rates ranges from 0.6 to 1.2 gallons per acre foot of water treated.

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Cutrine Plus

A 9% chelated copper algaecide for use in lakes, potable water reservoirs, farm ponds, fish and industrial ponds, fish hatcheries and raceways, crop and non-crop irrigation conveyance systems, ditches, canals, and laterals. Cutrine Plus, under field conditions, is effective in controlling a broad range of algae including Chara, Spirogyra, Cladophora, Vaucheria, Ulothrix, Microcystis, and Oscillatoria. Effective in hard water. Treated water may be used for swimming, fishing, drinking, livestock watering, or irrigation immediately after treatment. Application rates range from 0.6 to 1.2 gallons per acre foot of water treated.

This course contains EPA's federal rule requirements. Please be aware that each state implements pesticide regulations that may be more stringent than EPA's regulations and these frequently are changed. Check with your state environmental/pesticide agency for more information.

Cutrine Plus Granular

A 3.7% granular chelated copper algaecide ideally suited for treatment of bottom growing algae including Chara and Nitella and spot treatments along docks, beaches, boat launches, and fishing areas. This formulation helps control growth before it reaches the surface. Cutrine Plus Granular is registered for use in lakes, potable water reservoirs, farm and fish ponds, fish hatcheries, and golf course water hazards. Treated water may be used for swimming, fishing, drinking, livestock watering, or irrigation immediately after treatment. Spread as evenly as possible over treatment area at a rate of 1 pound per 750 square feet or 60 pounds per surface acre.

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Cutrine Plus Ultra

This formulation has the same active chelated copper content as Cutrine Plus with the addition of a non-ionic surfactant. Cutrine Plus Ultra is more effective against hard to control algae.

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GreenClean

GreenClean is a granular peroxide based product. This product is new to the industry for the 2004 season. The mode of action is oxidation, which provides immediate control of algae, and it releases oxygen as it works. GreenClean is one of the only non-copper based algaecides currently on the market. GreenClean can be applied by broadcasting, as a dissolved liquid, or as a subsurface application. Application rates range from 3-170 pounds per acre-foot depending on the amount of algae growth.

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Stocktrine

A chelated copper algaecide for use in small ponds, tanks, and troughs for control of filamentous and planktonic algae. Popular for use in small decorative pools. Easy to calculate and measure appropriate amount of material to be used in small volumes of water. Dosage rate is one ounce per 250 gallons. May be toxic to some ornamental fish.

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Attention! Pesticide Precautions

1. Observe all directions, restrictions and precautions on pesticide labels. It is dangerous, wasteful, and illegal to do otherwise.

2. Store all pesticides in original containers with labels intact and behind locked doors. KEEP PESTICIDES OUT OF THE REACH OF CHILDREN.

3. Use pesticides at correct label dosages and intervals to avoid illegal residues or injury to plants and animals.

4. Apply pesticides carefully to avoid drift or contamination of non-target areas.

5. Surplus pesticides and containers should be disposed of in accordance with label instructions so contamination of water and other hazards will not result.

6. Follow directions on the pesticide label regarding restrictions as required by state and federal laws and regulations.

7. Avoid any action that may threaten an endangered species or its habitat. Your county extension agent can inform you of endangered species in your area, help you identify them and through the Fish and Wildlife Service Field Office, identify actions that may threaten endangered species or their habitats.

Common Aquatic Herbicides

Aqua-Kleen

Aqua-Kleen is a granular formulation of 2,4-D which has been used for years for selective control of noxious aquatic plants, including water milfoil. This aquatic herbicide can also be used to manage aquatic plants such as coontail, water stargrass, spatterdock, and water lilies when considered nuisance. Aqua-Kleen does not affect most plants considered beneficial by water resource and fisheries managers; therefore, this herbicide works very well for spot treatments without impacting untreated areas of the water body. Suspension of water use for irrigation and domestic use based on testing for residual.

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Aqua-Pro

A concentrated systemic type herbicide infective against a variety of emergent aquatic and terrestrial grasses, broadleaf weeds, brush, and cattatils in and around aquatic sites, including lakes, rivers, streams, ponds, seeps, irrigation and drainage ditches, canals, and reservoirs. There is no restriction on the use of water for irrigation, recreation, or domestic purposes following application as described on the label. This product must be used with a non-ionic surfactant approved for the application site. We use Cide Kick II or Silenergy.

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Diquat dibromide

This is a contact herbicide that will control some, but not all, species of filamentous algae. It is applied by pouring directly from the container or by diluting with water and injecting below the water surface. For best results, it should be applied before algae growth reaches the surface. Diquat dibromide should not be used in muddy water. There are water-use restrictions associated with this material. Read the label.

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Aquathol K

A liquid concentrate soluble in water which is effective against a broad range of aquatic plants with a wide margin of safety to fish and other aquatic life. This product may be used in irrigation and drainage canals, ponds, and lakes. Aquathol K is a contact herbicide; consequently, do not apply before weeds are present. For best results water temperature should be at least 65°F. Restrictions on water usage following application are: livestock water, irrigation, and domestic use- 7 to 14 days; fish consumption - 3 days. Application rates range from 0.3 to 3.2 gallons/acre foot of water treated.

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Aquathol Super K

A concentrated granular herbicide effective against a broad range of aquatic plants with a wide margin of safety to fish and other aquatic life. The Super K pellets are manufactured in a manner which provides an essentially dust free material for easier application. The more concentrated formulation reduces the amount of material needed. Restrictions on water usage following application are: livestock water, irrigation, and domestic use - 7 days; fish consumption – 3 days. Application rates range from 2.2 to 22 pounds/acre foot of water treated.

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Endothall

The amine salt formulation of endothall (sold as Hydrothol 191) is labeled for algae control. It is available as a liquid or granular material. Endothall is a contact herbicide and is most effective in waters 65° F and above. Fish are extremely sensitive to this material. Read the label for water-use restrictions.

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DMA 4 IVM

An amine formulation of 2,4-D containing 46.3%(3.8 lb) active ingredient per gallon. DMA*4 IVM provides general aquatic weed control for susceptible emergent species, primarily broad-leaved plants and also controls brush and bullrushes. DMA*4 IVM is labeled for the control of water milfoil. Mix 2 to 4 quarts of DMA*4 IVM plus aquatic surfactant and drift control agent with 50-100 gallons of water per surface acre of foliage. For small areas use 2 ounces per gallon of water in sprayer. Available in 2.5 gallon containers.

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Nautique

Nautique is an effective copper based aquatic herbicide that is used to control hydrilla, naiads, brazilian elodea, widgeon grass, milfoil, sago pondweed, and horned pondweed. Nautique aquatic herbicide may be used in lakes, ponds, potable water reservoirs, ornamental ponds, golf course water hazards, fire ponds, and industrial retention basins. Water may be used immediately after treatment for swimming, fishing, livestock watering, and irrigation. Application rates range from 1.8 to 3.0 gallons per acre foot of water treated.

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Navigate

A granular formulation of 2,4-D which is effective on water milfoil, water stargrass, coontail, spatterdock, water lilies, and watershield. It is very effective in control of Eurasian watermilfoil, an aggressive, exotic species found throughout the U.S. This product is not for use in waters used for irrigation, agricultural sprays, watering dairy animals, or domestic water supplies. Recommended restrictions after application include no swimming for 1 day and no use of fish from treated waters for 3 days. Application rates vary from 100 pounds per acre for milfoil to a maximum of 200 pounds per acre for resistant plants such as spatterdock and watershield.

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Renovate 3

A systemic aquatic herbicide used for control of certain submersed, floating, and emergent aquatic plant species, including woody plants, in ponds, lakes, reservoirs, and marshes. Additional treatment sites include adjacent banks, shores, canal banks, and on non-irrigation canals which have little or no continuous outflow. Renovate 3 is an effective herbicide for water milfoil, purple loosestrife, and other "broadleaved" aquatic species. Renovate 3 will not harm "monocot" species such as cattails and grasses. Available in 2.5 gallon containers.

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Reward

A concentrated liquid aquatic herbicide effective against a wide variety of submersed, emergent, and floating aquatic plants including duckweed, naiads, and cattails. Reward poses virtually no environmental risk in aquatic applications because the herbicide concentration rapidly decreases as it is absorbed onto soil, vegetation, and organic matter. Restrictions on water usage following application: livestock consumption - 1 day; irrigation of food crops - 5 days; irrigation of turf and non-food crops- 1-3 days; human drinking - 1-3 days. The product of choice when fishing restrictions are not tolerable. Application rates: 1 to 2 gallons per surface acre.

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Sonar

An aquatic herbicide effective against a variety of submersed, emergent, and floating aquatic plants (including duckweed and watermeal). Provides excellent season-long control with an early spring application prior to or just after plant growth begins. Available in liquid and pelleted formulations. No restrictions on water use for fishing, swimming, or domestic use following application according to label instructions. Fourteen to thirty day restriction on use of treated water for irrigation following application. Application rates: Liquid: ponds - 0.16 to 1.5 quarts per acre; lakes - 0.11 to 4 quarts per acre. Pellets: ponds - 3.2 to 25 pounds per acre;, lakes - 4 to 80 pounds per acre.

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Weedtrine D

A non-volatile herbicide for use in controlling submersed and floating aquatic weeds. It is also recommended for top kill of shoreline emergent weeds and as a grass and broadleaf weed growth killer in non-crop or non-planted areas. Absorption and herbicidal action of Weedtrine D is usually quite rapid with effects visible in a few days. Application rates are 5-10 gallons per surface acre. Water should not be used for irrigation or domestic use for 5 days following treatment.

DISCLAIMER: The information in this profile does not in any way replace or supersede the information on the pesticide product labeling or other regulatory requirements. Please refer to the pesticide product labeling.

Acknowledgement for use of the herbicide information and for more information, please contact:

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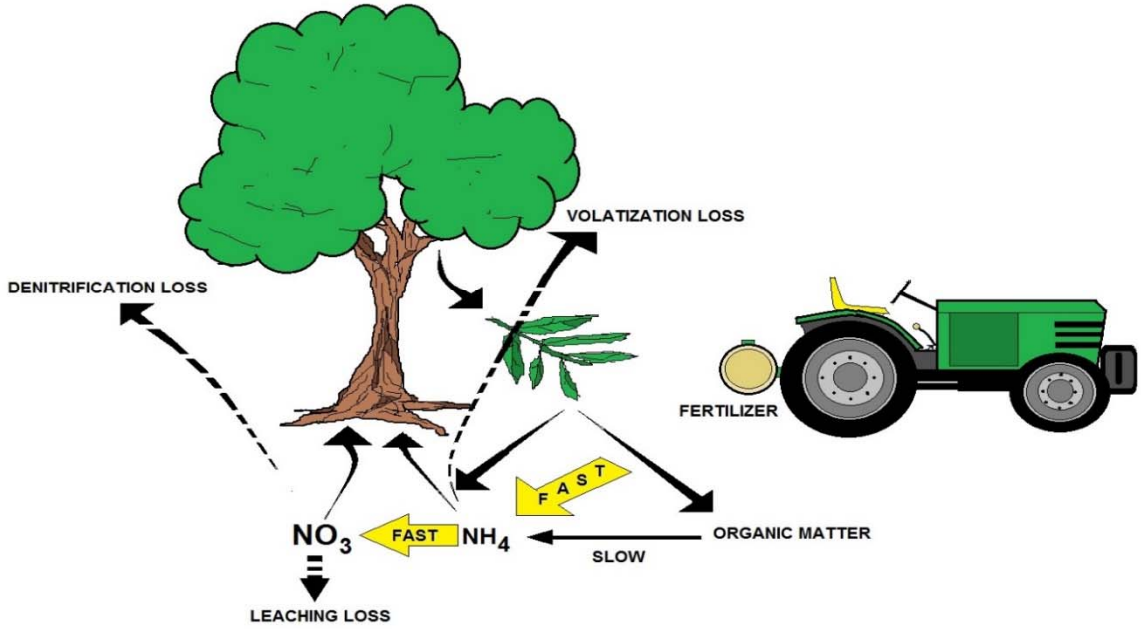


2017 Changes to EPA's Worker Protection Standard

In late 2015 the Environmental Protection Agency issued the long awaited revision to the Worker Protection Standard (WPS). This law it is now technically active and it will be enforced. Please keep in mind that the WPS covers both restricted use AND general use pesticides. This course is not for worker and/or handler training. Always follow the label and your State Pesticide Agency rules.

This course contains EPA's federal rule requirements. Please be aware that each state implements pesticide regulations that may be more stringent than EPA's regulations and these frequently are changed. Check with your state environmental/pesticide agency for more information.

Inert Dyes

Inert dyes can be used to control algae. The color they turn the water, usually blue, reduces sunlight penetration, which in turn reduces growth of algae and submerged weeds. These dyes are not effective in water less than 2 feet deep or if the alga is floating on the water surface. Most inert dyes are labeled for all water uses except domestic drinking water supplies. Check the label.

Table 1. Aquatic Herbicides for Filamentous Algae Control (except Pithophora)

Labeled Herbicides		Waiting Period Before Water Used For:					
		Human			Animal	Irrigation	
Trade Name	Chemical Name	Drinking	Swimming	Fishing	Drinking	Turf	Food Crops
AlgaePro	Copper chelate	0 days	0 days	0 days	0 days	0 days	0 days
Aquashade, Aquashadow	(Inert dye)	Not permitted	24 hours (note 1)	0 days	0 days	0 days	0 days
Copper sulfate	Copper sulfate	0 days (note 2)	0 days (note 2)	0 days	0 days (note 2)	0 days	0 days
Cutrine Plus (liquid and granular)	Copper chelate	0 days	0 days	0 days	0 days	0 days	0 days
Diquat/ Reward (note 3)	Diquat dibromide	14 days	24 hours	0 days	14 days	14 days	14 days
Hydrothol 191	Endothall	7-14 days (note 4)	24 hours	3 days	7-14 days (note 4)	Not permitted	7-14 days (note 4)

Notes to Table 1: 1 - Wait for complete dispersal before swimming.
2 - No required waiting period. 24-hour waiting period recommended to allow for dissipation of metallic odor.
3 - Controls some species of algae: Spirogyra and Pithophora.
4 - Varies by application rate used.
5 - Copper is toxic to fish eggs and fish fry.
6 - Production of this material has been terminated, but it may be purchased and used until supplies are exhausted.

Table 1. (Continued) Aquatic Herbicides for Filamentous Algae Control (except Pithophora)					
Labeled Herbicides		**Characteristics**			
Trade Name	**Chemical Name**	**Min/Max Water Temp.**	**Biodegradable**	**Fish Toxicity at Recommended Rates**	**Observable Effects**
AlgaePro	Copper chelate	60 F/None	Partial	note 5	7-10 days
Aquashade, Aquashadow	(Inert dye)	None	Yes	No	Varies
Copper sulfate	Copper sulfate	60 F/None	No	note 5	3-5 days
Cutrine Plus (liquid and granular)	Copper chelate	60 F/None	Partial	note 5	7-10 days
Diquat/ Reward (note 3)	Diquat dibromide	60 F/None	Adheres to soil	No	7 days
Hydrothol 191	Endothall	65 F/None	Yes	Yes	3-14 days

Notes to Table 1: 1 - Wait for complete dispersal before swimming.
2 - No required waiting period. 24-hour waiting period recommended to allow for dissipation of metallic odor.
3 - Controls some species of algae: Spirogyra and Pithophora.
4 - Varies by application rate used.
5 - Copper is toxic to fish eggs and fish fry.
6 - Production of this material has been terminated, but it may be purchased and used until supplies are exhausted.

The Right Chemical

Will the chemical achieve the results desired? This question may seem too obvious, but it is one that is often overlooked by pond owners. For example, no single aquatic herbicide is capable of controlling all kinds of weeds that are potential pond management problems. Most chemicals used to control weeds, diseases, and other aquatic pests are expensive and are effective only on certain pest organisms. For this reason, it is important to accurately identify the aquatic pest or the water quality problem before purchasing and applying a chemical to a pond. Your county extension agent or state fisheries biologist can assist you in identifying the pest or the water quality problem.

Once you have accurately identified the problem, then select the most effective control measure. This does not mean that a chemical can or should be used to correct every pond management problem. The best approach is to consider preventive measures first. If they are not practical or do not produce the desired results, then other control methods should be considered. It is always easier and more economical to prevent a problem than to cure one. Even when preventive measures are only partially successful, they quite often facilitate the effectiveness of other control measures. Preventive measures may or may not include the use of chemicals.

Matching the management problem with an effective chemical is not enough. You must also consider the effect that chemicals may have on non-target organisms.

For example, some chemicals used to treat diseases in fish are also toxic to plants. Use of these chemicals during the summer months may cause oxygen depletion. Also, the water chemistry and its effect on the chemical may need to be considered. Some chemicals break down rapidly in the presence of sunlight, high pH, and high temperature and are less likely to be effective during the hot summer months. Be sure to consider other water uses and effects the chemical may have on them. For example, aquatic herbicides applied to a pond used for irrigation may have a disastrous effect upon the irrigated crops. Also, consider the effects the chemical may have downstream from your pond.

Whenever you use a chemical in a pond, it must be applied properly and all warnings and precautions concerning use must be understood and observed. Fortunately, all of this information is on the label for most chemicals approved for use in ponds. Anyone who uses a chemical in a pond should always thoroughly read and understand the chemical label before purchasing and applying it.

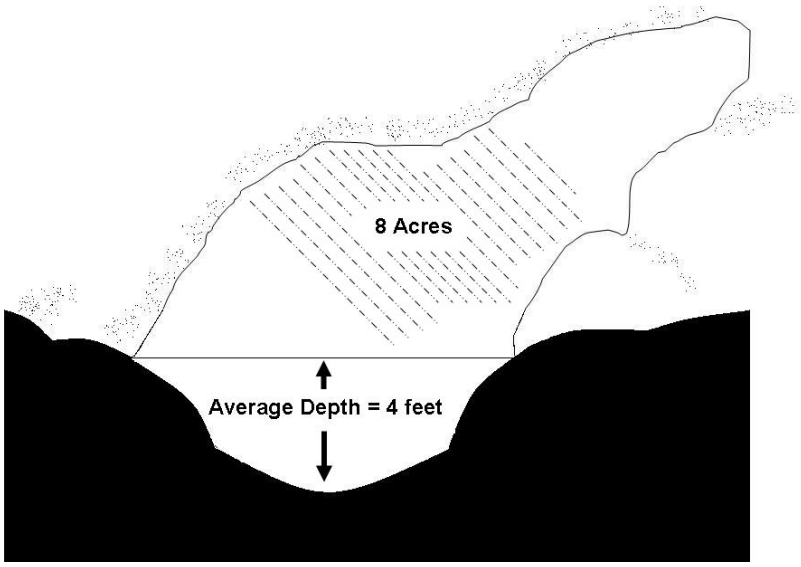
Obviously the effectiveness of some chemical treatments can be quite variable. If you are not certain of the identification of the aquatic pest or the best control method, consult your county extension agent or state fisheries biologist. Assuming you have selected the most effective chemical for use, the following information should be used to determine the proper amount to apply and to determine the best and safest way to apply it.

Calculation of Chemical Treatments Applied to Pond Water

The following information is essential in computing the amount of chemical to apply to a pond: the pond water volume, the chemical formulation, and the effective concentration of the chemical needed in the pond water to correct the problem.

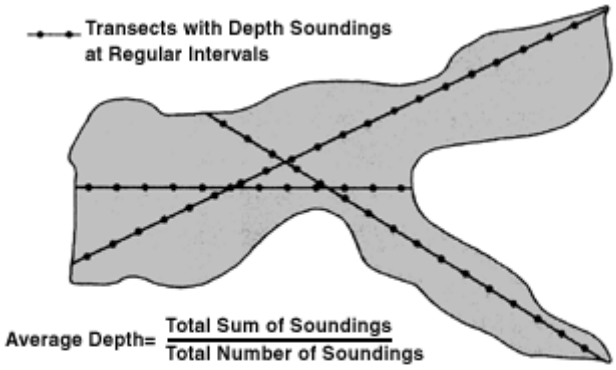
Pond Water Volume

Every pond owner should know the water volume of his pond. Volume can be expressed as cubic feet, cubic meters, gallons, liters, etc. However, because of the rather large numbers involved with these units, the common measure used for pond water volume is acre-feet. For example, a pond of eight surface acres with an average depth of four feet would contain 10,432,000 gallons of water. This equals 32 acre-feet of water.



An acre-foot is one surface acre one foot deep. Acre-feet are computed by multiplying the area (in acres) by the average depth (in feet). In the example above, eight surface acres times the average depth of four feet equals 32 acre-feet of water.

Most county Natural Resources Conservation Service offices can assist pond owners in determining the water volume of their ponds. The surface acreage of most ponds can also be determined by county Farm Service offices. Assuming the surface acreage of a pond is known, the following method can be used to determine the average depth of a pond. Average depth can be determined by use of a sounding line at regular intervals along several transects of the pond. Both deep and shallow area of the pond should be included in the transects.



$$\text{Average Depth} = \frac{\text{Total Sum of Soundings}}{\text{Total Number of Soundings}}$$

$$\text{Example: } 3.5' = \frac{1' + 2.5' + 4' + 4.5' + 4.5' + 4' + 6' + 4' + 4' + 4' + 2.5' + 1'}{12}$$

Average depth is computed by adding all of the depth measurements and dividing by the number of measurements to get the average. The average depth multiplied by the surface area should give an accurate estimate of the pond water volume.

Know the water volume of your pond before a treatment is needed. You can lose valuable time if the determination must be made after a problem has arisen. Table 1 can be used to convert acre feet into other measures of water volume.

Table 1. Equivalents of 1 acre foot of water

1 acre-foot	= 43,560 cubic feet
	= 4,840 cubic yards
	= 326,000 gallons (approximately)
	= 2,780,000 pounds (approximately)

Chemical Formulations

Chemical formulations vary in the amount of active ingredients present. The active ingredients are the chemicals which actually kill the pest or correct the undesirable water quality problem. Inert ingredients are added to improve the convenience, safety and handling of the chemical.

For a particular chemical, the application rate is based upon the amount of active ingredient in the chemical formulation. Fortunately, the amount of active ingredients contained in the chemical formulation and the application rate are printed on most product labels. This is one reason why it is important to read the information printed on the label.

Effective Chemical Concentration

In treating a pond, chemicals are added to the water to produce an effective concentration of active ingredients that will eliminate the pest or correct the water quality problem. Desired concentrations are usually expressed as parts per million, usually written as ppm.

One part per million is equivalent to the ratio of one pound of chemical to 999,999 pounds of water or one gram of chemical to 999,999 grams of water. In other words, one part per million equals one pound or one gram in one million pounds or grams of a solution or mixture, respectively.

Notice that parts per million is a weight-to-weight relation. Units of volume cannot be used directly. This is because an equal volume of two different chemicals may have considerably different weights. For example, one cubic-foot of lead weighs much more than one cubic-foot of water.

Calculation of Pond Water Treatments

The following formula can be used to determine the amount of chemical needed to treat a pond:

Amt of Chemical = Volume x CF x ECC x AI Needed

Where:

Volume = Volume of water to be treated. Although the unit of measure can be in gallons, liters, cubic feet, cubic yards, etc., when treating ponds, the more common and easier to use expression of volume is acre-feet.

CF = Conversion factor, a figure that equals the weight of a chemical to be used to give one part per million (ppm) in a given unit volume of water.

Table 2 lists conversion factors (CF) for various measures of volume. For example, select the CF that corresponds to the unit of measure used for pond volume. For example, if the pond volume is measured in acre-feet, the appropriate CF is 2.72 if the chemical weight is measured in pounds or 1,233 if weight is measured in grams.

Table 2. Conversion Factors (CF) - Weight of Chemical in One Unit Volume of Water to Give One Part Per Million ppm.

2.72 pounds per acre-foot	= 1 ppm
1,233 grams per acre-foot	= 1 ppm
0.0283 grams per cubic foot	= 1 ppm
0.0000624 pounds per cubic foot	= 1 ppm
0.0038 grams per gallon	= 1 ppm
0.0584 grains per gallon	= 1 ppm
1 milligram per liter	= 1 ppm
0.001 gram per liter	= 1 ppm
8.34 pounds per million gallons of water	= 1 ppm

ECC = Effective chemical concentration of active ingredients needed in the pond water to eliminate the pest or correct a water quality problem. This unit of measure must be in ppm.
AI = The total amount of active and inert ingredients divided by the amount of active ingredients. Products, which are liquid formulations, usually list the amount of active ingredients as pounds active per gallon. For such products AI = 1 gallon divided by the pounds per gallon of active ingredients. A few chemicals are liquids in their pure form and their specific gravity must be known to calculate AI. See Example 4 to calculate AI using specific gravity.

Non-liquid formulations usually list active ingredients as a percentage of the total formulation. For nonliquid formulations, AI = 100% divided by the percentage of active ingredients.

The following examples illustrate how the equation previously mentioned can be used in calculating pond water treatments.

Example 1. How much Chemical A is needed to treat a pond that has 4 surface acres and an average depth of 3 feet with 2 ppm active ingredient? Chemical A is 100% active.

Volume	= 4 acres x 3 feet
CF	= 12 acre-feet
ECC	= 2.72 pounds (from Table 2)
AI	= 2 ppm (active ingredient needed in the water)
	= 100%
	100% (Chemical A is 100% active)

The amount of Chemical A needed is found by substituting the above values in the formula:

Volume x CF x ECC x AI

Thus: (12 acre-feet x 2.72 pounds x 2 ppm x 100) / 100 = 65.3 pounds of Chemical A are needed to treat the pond.

Example 2. How much Chemical B (80 percent active) is needed to treat a pond measuring 1,000 feet long by 500 feet wide by 5 feet deep with a concentration of 0.25 ppm active ingredient?

Volume	= 100 feet x 50 feet x 5 feet
	= 25,000 cubic feet
CF	= 0.0000624 pounds/cubic foot (from Table 2)
ECC	= 0.25 ppm (active ingredient needed in the water)
AI	= 100%
	80%

The amount of Chemical B needed is found by substituting the above values in the formula.

Volume x CF x ECC x AI

Thus: (25,000 cu. ft. x 0.0000624 pounds/cu.ft. x 0.25 ppm x 100) / 80 = 0.49 pounds of Chemical B (80 percent) are needed to treat the pond.

Example 3. How much Chemical C (2 pounds active per gallon) is needed to treat a pond that has 6 surface acres and an average depth of 4 feet with 0.5 ppm active ingredient?

Volume	= 6 acres x 4 feet
	= 24 acre-feet
CF	= 2.72 pounds/acre-foot (From Table 2)
ECC	= 0.5 ppm (active ingredient needed in water)
AI	= 1 gal.
	2 lbs.

The amount of Chemical C needed is found by substituting the above values in the formula:

Volume x CF x ECC x AI

Thus: (24 acre-feet x 2.72 pounds/acre-foot x 0.5 ppmx 1 gal) / 2 lbs = 16.3 gallons of Chemical C (2 lbs active/gallon) are needed to treat the pond.

Example 4. How much Chemical D is needed to treat a pond measuring 180 feet long by 90 feet wide by 4 feet deep with a concentration of 25 ppm active ingredient. Chemical D is a liquid and is 100 percent active.

Volume	= 180 feet x 90 feet x 5 feet
CF	= 81, 000 cubic feet
ECC	= 0.0000624 pounds per cubic foot
AI	= 25 ppm
	= 100%
	100%

The amount of Chemical D needed is found by substituting the above values in the formula:

Volume x CF x ECC x AI

Thus: (81,000 cu. ft. x 0.0000624 pounds/cu.ft. x 25 ppm x 100) / 100 =126.4 pounds of Chemical D
However, Chemical D is a liquid and 126.4 pounds must be converted to a unit of volume. Since (ppm) parts per million is a weight-to-weight relation, it is necessary to know how Chemical D compares in weight with water. Chemical D is heavier than water, thus a smaller amount of Chemical D is needed to equal 250 ppm in water on a Chemical D to water weight-to-weight ratio. Chemical D weighs about 9 pounds per gallon and water 8.34 pounds per gallon; or Chemical D is 1.08 times as heavy as water (9 divided by 8.34). This figure is called the specific gravity (SG) of Chemical D. If the weight of Chemical D is computed in grams, the weight divided by the specific gravity equals the number of cubic centimeters required. If the weight (as in this example = 126.4 pounds) is computed in pounds, divide by 8.34 times the specific gravity to convert it to gallons. In this example the amount of Chemical D needed is:

(126.4 pounds) / (8.34 lbs/gal x 1.08 SG) = 140 gallons

Treatment Methods
Selection of the best treatment method depends upon the specific situation and the chemical used in treatment. The following treatment methods can be used.

Treatments Applied to Pond Water

1. **Surface - applied treatments**
   Contact pesticides, inorganic fertilizers, lime, and a few other water quality control chemicals are applied to ponds at a rate based upon the surface acreage of the pond - not the pond's water volume. Generally, these chemicals are either sprayed or broadcasted over the pond surface.
2. **Total water column water treatments**
   This is the most common technique of chemical treatment used in a pond. The whole volume of water (water column) in the pond is treated. The pond water volume is calculated and the chemical is added to reach a specific dilution in the water column. An alternative is to calculate the entire volume and then treat only one-fourth or one-third of the total water column, based on surface area, confining the treatment to selected sections of the pond where the pest infestation may be more intense. Specific application techniques include injection directly into the water with undiluted chemical, or some dilution of the chemical sprayed or cast upon the surface of the water. With either method, further dispersal throughout the water column is dependent upon water currents.
3. **Bottom acre-foot treatments**
   This is a specialized application technique which is intended primarily for control of submersed aquatic vegetation. A boat carrying application equipment drags a hose or boom over and just above the pond bottom. The chemical is dispersed through nozzles, and the specific gravity of the chemical causes the treatment to remain near the bottom and in proximity of the rooted submersed weeds.

Specialized Treatments

Generally, the treatment methods described below require either the fish to be removed from the culture area being treated and then returned, or instead of treating the culture water to remove a pest, the fish themselves are treated with a chemical, usually incorporated into their feed.

1. **Dip Method**
   This involves exposure of the fish to a strong solution of chemical for a short period of time. Fish are usually netted and dipped into a chemical and returned to the culture area.

2. **Flush Method**
   This method is only applicable in tanks, raceways, or egg incubators. A stock solution of a chemical is applied in the upper end of the unit and allowed to flush throughout the system. The chemical must flush through the system in a predetermined time.

3. **Bath Treatments**
   Bath treatments involve application of a chemical directly to the culture area and after a specified time, flushing it from the rearing unit. Bath treatments may be commonly used in culture tanks but are difficult to apply in ponds because most managers do not have an adequate water supply to flush the pond after treatment.

4. **Feeding Method**
   Feeding involves the incorporation of a drug or medication in a feed, or in some other way introduces the chemical into the stomach of the fish. This treatment is the most common method used in treating bacterial infections and internal parasites of fish.

5. **Injection Method**
   Some medications and drugs can be injected into fish for effective control of a disease. It is generally not practical in pond or intensive culture systems unless the fish have a high economic value.

2017 Changes to EPA's Worker Protection Standard

In late 2015 the Environmental Protection Agency issued the long awaited revision to the Worker Protection Standard (WPS). This law it is now technically active and it will be enforced. Please keep in mind that the WPS covers both restricted use AND general use pesticides. This course is not for worker and/or handler training. Always follow the label and your State Pesticide Agency rules.

This course contains EPA's federal rule requirements. Please be aware that each state implements pesticide regulations that may be more stringent than EPA's regulations and these frequently are changed. Check with your state environmental/pesticide agency for more information.

Conversions

Table 3. Conversions for Units of Volume

From / To	CM^3	liter	M^3	IN^3	ft^3	fl.oz.	fl. pt.	fl.qt.	gal.
CM^3	1	0.001	$1x10^{-6}$	0.0610	$3.53x10^{-5}$	0.0338	0.00211	0.00106	$2.64x10^{-4}$
liter	1000	1	0.001	60.98	0.353	33.81	2.113	1.057	0.2642
M^3	$1x10^6$	1000	1	$6.1x10^4$	35.31	$3.38x10^4$	2113	1057	264.2
IN^3	16.39	0.0164	$1.64x10^{-5}$	1	$5.79x10^{-4}$	0.5541	0.0346	0.0173	0.0043
ft^3	$2.83x10^4$	28.32	0.0283	1728	1	957.5	59.84	29.92	7.481
fl. oz.	29.57	0.0296	2.96×10^{-5}	1.805	0.00104	1	0.0625	0.0313	0.0078
fl. pt.	473.2	0.4732	$4.73x10^{-4}$	28.88	0.0167	16	1	0.5	0.125
fl.qt.	946.2	0.9463	$9.46x10^{-4}$	57.75	0.0334	32	2	1	0.25
gal.	3785	3.785	0.0038	231.0	0.1337	128	8	4	1

Table 4. Conversions for Units of Length

From / To	cm	m	in.	ft.	yd
cm	1	0.01	0.3937	0.0328	0.0109
m	100	1	39.37	3.281	1.0936
in.	2.54	0.0254	1	0.0833	0.0278
ft.	30.48	0.3048	12	1	0.3333
yd.	91.44	0.9144	36	3	1

Table 5. Conversion for Units of Weight

From / To	g	kg	gr.	oz.	lb.
g	1	0.001	15.43	0.0353	0.0022
kg	1000	1	1.54×10^5	35.27	2.205
gr.	0.0648	6.48×10^5	1	0.0023	1.43×10^{-4}
oz.	28.35	0.0284	437.5	1	0.0625
lb.	453 6	0.4536	7000	6	1

Table 6. Miscellaneous Conversion Factors

1 acre-foot	43,560	cubic feet
1 acre-foot	325,580	gallons
1 acre-foot of water	2,718,144	pounds
1 cubic-foot of water	62.4	pounds
1 gallon of water	8.34	pounds
1 gallon of water	3,785	grams
1 liter of water	1,000	grams
1 fluid ounce	29.57	grams

Helpful Formulas for Determining Volume

1. Volume of a square or rectangle container = length x width x depth
2. Volume of a circular container = 3.14 x radius^2 x depth
3. Volume of a pond = surface acres x average depth = acre-feet

Abbreviations

cm	=	centimeter
cm^3	=	cubic centimeter
fl oz	=	fluid ounce
fl pt	=	fluid pint
fl qt	=	fluid quart
ft	=	foot
ft^3	=	cubic foot
gal	=	gallon
g	=	gram
gr	=	grain
in	=	inch
in^3	=	cubic inch
kg	=	kilogram
lb	=	pound
m	=	meter
m^3	=	cubic meter
oz	=	ounce
yd	=	yard

Glyphosate

Disclaimer* Herbs are not a replacement for pharmaceutical drugs. If you are unfamiliar with how to use an herb, ask your herbalist or healthcare professional before using the herb. Never use any of these herbs unless you have been personally trained by an herbalist or healthcare professional. Herbs can cause death or serious illness.

USE PESTICIDES WISELY: ALWAYS READ THE ENTIRE PESTICIDE LABEL CAREFULLY, FOLLOW ALL MIXING AND APPLICATION INSTRUCTIONS AND WEAR ALL RECOMMENDED PERSONAL PROTECTIVE GEAR AND CLOTHING. CONTACT YOUR STATE DEPARTMENT OF AGRICULTURE FOR ANY ADDITIONAL PESTICIDE USE REQUIREMENTS, RESTRICTIONS OR RECOMMENDATIONS.

NOTICE: MENTION OF PESTICIDE PRODUCTS IN THIS COURSE DOES NOT CONSTITUTE ENDORSEMENT OF ANY MATERIAL OR HERB OR HERBAL SUPPLEMENT.

Topic 10 Aquatic Herbicides and Controls Section
Post Quiz Answers at the rear of Glossary

Fill-in-the-blank

1. Endothall is an organic solid of white odorless crystals. Endothall is used as a defoliant for a wide range of crops and as a herbicide for both terrestrial and aquatic weeds. It is used as a _____on lucerne and on potato, for the defoliation of cotton, to control aquatic weeds and as an aquatic algaecide growth regulator. It has been used for: sugar beets, turf, hops sucker suppression; alfalfa, clover desiccants; potato vine killers.

2. Breakdown in soil and groundwater: Diquat dibromide is highly persistent, with reported field half-lives of greater than 1000 days. It is very well sorbed by soil organic matter and clay. Although it is_____, its capacity for strong adsorption to soil particles suggest that it will not easily leach through the soil, be taken up by plants or soil microbes, or broken down by sunlight (photochemical degradation). Field and laboratory tests show that diquat usually remains in the top inch of soil for long periods of time after it is applied.

Glyphosate

3. Glyphosate is a _____used for control of annual and perennial plants including grasses, sedges, broad-leaved weeds, and woody plants. It can be used on non-cropland as well as on a great variety of crops.

4. Glyphosate itself is an acid, but it is commonly used in_____, most commonly the isopropylamine salt. It may also be available in acidic or trimethylsulfonium salt forms. It is generally distributed as water-soluble concentrates and powders.

5. Triclopyr can be effective for _____of Eurasian watermilfoil and is relatively selective to Eurasian watermilfoil when used at the labeled rate. Many native aquatic species are unaffected by triclopyr. Triclopyr is very useful for purple loosestrife control since native grasses and sedges are unaffected by this herbicide. When applied directly to water, Ecology has imposed a 12-hour swimming restriction to minimize eye irritation.

6. _____can show good control of submersed plants where there is little water movement and an extended time for the treatment. Its use is most applicable to whole-lake or isolated bay treatments where dilution can be minimized. It is not effective for spot treatments of areas less than five acres. It is slow-acting and may take six to twelve weeks before the dying plants fall to the sediment and decompose.

7. Most species of algae can be controlled with_____. It is available in crystalline nuggets the size of rock salt or as a finely ground "snow" grade. The recommended treatment rate is 2.7 pounds per acre-foot of water. Acre-feet is a volume measurement of the pond. It is determined by multiplying average depth (feet) X surface area (acres). For more information on calculating measurements, see the prior section in this book. When uniformly applied, this will result in a 1 part per million (ppm) concentration throughout the volume of the pond. For very hard water (more than 12 grains or 200 parts per million of hardness), this rate should be doubled.

Cutrine Plus

8. A 9% chelated copper algaecide for use in lakes, potable water reservoirs, farm ponds, fish and industrial ponds, fish hatcheries and raceways, _____conveyance systems, ditches, canals, and laterals. Cutrine Plus, under field conditions, is effective in controlling a broad range of algae including Chara, Spirogyra, Cladophora, Vaucheria, Ulothrix, Microcystis, and Oscillatoria. Effective in hard water. Treated water may be used for swimming, fishing, drinking, livestock watering, or irrigation immediately after treatment. Application rates range from 0.6 to 1.2 gallons per acre foot of water treated.

9. A concentrated granular herbicide effective against a broad range of aquatic plants with a wide margin of safety to fish and other aquatic life. The Super K pellets are manufactured in a manner which provides_____. The more concentrated formulation reduces the amount of material needed. Restrictions on water usage following application are: livestock water, irrigation, and domestic use - 7 days; fish consumption – 3 days. Application rates range from 2.2 to 22 pounds/acre foot of water treated.

10. _____following application: livestock consumption - 1 day; irrigation of food crops - 5 days; irrigation of turf and non-food crops- 1-3 days; human drinking - 1-3 days. The product of choice when fishing restrictions are not tolerable. Application rates: 1 to 2 gallons per surface acre.

Topic 11 Invasive Plant Rule Section

An invasive species is a non-native species whose introduction does or is likely to cause economic or environmental harm or harm to human, animal, or plant health. The National Invasive Species Management Plan indicates that NISC will focus on non-native organisms known to cause or likely to cause negative impacts and that do not provide an equivalent or greater benefit to society. In the technical sense, the term 'invasion' simply denotes the uncontrolled or unintended spread of an organism outside its native range with no specific reference about the environmental or economic consequences of such spread or their relationships to possible societal benefits. However, the policy context and subsequent management decisions necessitate narrowing what is meant and what is not meant by the term *invasive species.* Essentially, we are clarifying what is meant and not meant by "causing harm" by comparing negative effects caused by a non-native organism to its potential societal benefits.

Weeds As Examples
Weeds provide good examples to clarify what is meant by an invasive species because most people have a concept of what constitutes a "weed."

Invasion can be thought of as a process that in our example, a plant must go through to become a successful, yet harmful invader. Several barriers must be overcome for a plant to be considered an invasive weed. Invasive weeds are invasive species.

Large-scale geographical barriers
First, a geographical barrier must be overcome, which often occurs as a mountain range, ocean, or similar physical barrier to movement of seeds and other reproductive plant parts. Plants that overcome geographical barriers are known as alien plants or alien species. Alien plants are non-native plants and alien species are non-native species. Therefore, non-native plants are those that occur outside their natural range boundaries, and this most often is mediated by humans either deliberately or unintentionally.

Survival barriers
The second set of obstacles that a non-native plant must overcome is barriers to germination and survival in its new location. These typically are environmental barriers such as adequate moisture availability to allow successful germination and survival of seedlings that will continue to grow to maturity. Other physical barriers might be soil pH, nutrient availability, or competition for resources from neighboring plants.

Establishment barriers
The third obstacle that a non-native plant must overcome to be considered an invasive weed, is to form a population that is self-sustaining and does not need re-introduction to maintain a population base such that it continues to survive and thrive in its new environment. Once this occurs, this population of non-native plants is considered to be established. Environmental barriers to survival and establishment are similar.

Dispersal and spread barriers
Established non-native plants must overcome barriers to dispersal and spread from their site of establishment to be considered invasive plants. Additionally, the rate of spread must be relatively fast. However, this movement or spread alone does not necessarily make this non-native plant an invasive weed or invasive species.

Harm and impact
Finally, a plant is deemed to be invasive if it causes negative environmental, economic, or human health effects, which outweigh any beneficial effects. For example, yellow starthistle is a source of nectar for bee producers. But the displacement of native and other desirable plant species caused by yellow starthistle leads to dramatically decreased forage for wildlife and livestock, which severely

disrupts the profitability of associated businesses. These negative effects greatly overshadow the positive effects and thus, define harm caused by yellow starthistle and explain why it is considered an invasive species.

California
Invasive plants are one of the most serious environmental issues facing California. They disrupt ecosystems by altering physical processes, displacing native plants, and degrading wildlife habitat. The California Invasive Plant Inventory is a vital resource for those working to protect the state's natural areas. The Inventory summarizes the impacts, potential for spread, and distribution of more than 200 non-native plants that invade wildlands in California. The Inventory represents the best available knowledge of the state's invasive plant experts. It is designed to prioritize plants for control at the state and local levels, to provide key information to those working in habitat restoration, to show areas where research is needed, to aid those preparing or commenting on environmental planning documents, and to educate public policy makers. Detailed assessments for each plant, with documented sources, are available online at **www.cal-ipc.org**.

California Invasive Plant Council
Protecting California's wildlands from invasive plants through research, restoration, and education.
www.cal-ipc.org

The California Invasive Plant Council (Cal-IPC) formed as a non-profit organization in 1992 to address the growing ecological and economic impacts caused by invasive plants in California's wildlands. They promote research, restoration, and education in pursuit of this goal. Formerly known as the California Exotic Pest Plant Council, Cal-IPC is a member-driven organization with land managers, researchers, policy makers, and concerned citizens working together to protect the state's natural areas from invasive plants. For more information, visit their website at www.cal-ipc.org. It may also be part of your assignment.

Providing Input for Future Revisions
If you have additional information to add to a plant assessment, please submit it to info@cal-ipc.org. The Inventory Review Committee will meet periodically to consider additions and modifications to the Inventory.

Invasive plants damage ecosystems around the world. They displace native species, change plant community structure, and reduce the value of habitat for wildlife.

Invasive plants may disrupt physical ecosystem processes, such as fire regimes, sedimentation and erosion, light availability, and nutrient cycling. In aquatic ecosystems, invasive plants clog lakes, streams, and waterways, reducing oxygen levels for fish and degrading habitat for waterbirds. The impact is especially severe in California, with its rich diversity of natural resources. The California Invasive Plant Inventory categorizes non-native invasive plants that threaten the state's wildlands. Categorization is based on an assessment of the ecological impacts of each plant.

The Inventory represents the best available knowledge of invasive plant experts in the state. However, it has no regulatory authority, and should be used with full understanding of the limitations described later in this Introduction. California is home to 4,200 native plant species, and is recognized internationally as a "biodiversity hotspot." Approximately 1,800 non-native plants also grow in the wild in the state. A small number of these, approximately 200, are the ones that this Inventory considers invasive. Improved understanding of their impacts will help those working to protect California's treasured biodiversity.

The Inventory
The Inventory categorizes plants as High, Moderate, or Limited, reflecting the level of each species' negative ecological impact in California. Other factors, such as economic impact or difficulty of management, are not included in this assessment.

It is important to note that every species listed in Table 1 is invasive, regardless of its overall rating, and should be of concern to land managers. Although the impact of each plant varies regionally, its rating represents cumulative impacts statewide. Therefore, a plant whose statewide impacts are categorized as Limited may have more severe impacts in a particular region. Conversely, a plant categorized as having a High cumulative impact across California may have very little impact in some regions.

Members of the Inventory Review Committee, Cal-IPC staff, and volunteers drafted assessments for each plant based on the formal criteria system described below. The committee solicited information from land managers across the state to complement the available literature. Assessments were released for public review before the committee finalized them. All plant assessments that form the basis for this summary document are available at www.cal-ipc.org. The final list includes 39 High species, 65 Moderate species, and 89 Limited species.

Additional information, including updated observations, will be added to the Cal-IPC website periodically, with revisions tracked and dated.

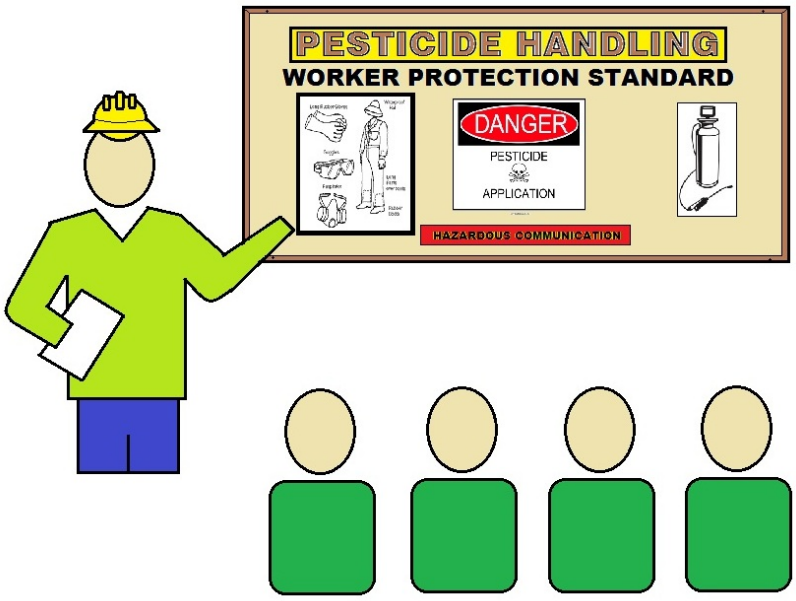
Definitions

The Inventory categorizes “invasive non-native plants that threaten wildlands” according to the definitions below. Plants were evaluated only if they invade California wildlands with native habitat values. The Inventory does not include plants found solely in areas of human-caused disturbance such as roadsides and cultivated agricultural fields.

• **Wildlands** are public and private lands that support native ecosystems, including some working landscapes such as grazed rangeland and active timberland.

• **Non-native** plants are species introduced to California after European contact and as a direct or indirect result of human activity.

• **Invasive non-native plants that threaten wildlands** are plants that 1) are not native to, yet can spread into, wildland ecosystems, and that also 2) displace native species, hybridize with native species, alter biological communities, or alter ecosystem processes.



PESTICIDE RULE TRAINING IS REQUIRED

CalEPPC Inventory List

The California Exotic Pest Plant Council Plant Inventory List

Legend
F: Federal Noxious Weed, as designated by the USDA; targeted for federally-funded prevention, eradication or containment efforts.
A: CA Dept. of Food & Agriculture, on .A. list of Noxious Weeds; agency policies call for eradication, containment or entry refusal.
B: CA Dept. of Food & Agriculture, on .B. list of Noxious Weeds; includes species that are more widespread, and therefore more difficult to
contain; agency allows county Agricultural Commissioners to decide if local eradication or containment is warranted.
C: CA Dept. of Food & Agriculture, on .C. list of Noxious Weeds; includes weeds that are so widespread that the agency does not endorse
state or county-funded eradication or containment efforts except in nurseries or seed lots.
Q: CA Dept. of Food & Agricultures designation for temporary .A. rating pending determination of a permanent rating.
For most species nomenclature follows The Jepson Manual: Higher Plants of California (Hickman, J., Ed., 1993).

Distribution Regions - Distribution by geographic subdivisions per the Jepson Manual

CA=California
CA-FP=California Floristic Province
CaR=Cascade Ranges
CaRF=Cascade Range Foothills
CCo=Central Coast
ChI=Channel Islands
CW=Central Western CA
D=Deserts
DMoj=Mojave Desert
DSon=Sonoran Desert
GB=Great Basin
GV=Great Valley
KR=Klamath Ranges
MP=Modoc Plateau
NCo=North Coast
NCoRI=Inner NCo Ranges
NCoRO=Outer NCo Ranges
NW=Northwestern CA
PR=Peninsular Ranges
SCo=South Coast
SCoRI=Inner SCo Ranges
SCoRO=Outer SCo Ranges
ScV=Sacramento Valley
SnJV=San Joaquin Valley
SN=Sierra Nevada
SNE=East of SN
SNF=SN Foothills
SNH=High SN
SnFrB=San Francisco Bay Area
SnGb=San Gabriel Mtns
SW=Southwestern CA
Teh=Tehachapi Mtns
WTR=Western Transverse Ranges

Exotic Pest Plants of Greatest Ecological Concern in California

The following Inventory categorizes "invasive non-native plants that threaten wildlands" according to the definitions below. Plants were evaluated only if they invade California wildlands with native habitat values. The Inventory does not include plants found solely in areas of human-caused disturbance such as roadsides and cultivated agricultural fields.

- Wildlands are public and private lands that support native ecosystems, including some working landscapes such as grazed rangeland and active timberland.
- Non-native plants are species introduced to California after European contact and as a direct or indirect result of human activity.
- Invasive non-native plants that threaten wildlands are plants that 1) are not native to, yet can spread into, wildland ecosystems, and that also 2) displace native species, hybridize with native species, alter biological communities, or alter ecosystem processes.

Each plant on the list received an overall rating of High, Moderate or Limited based on evaluation using the criteria system. The meaning of these overall ratings is described below. In addition to the overall ratings, specific combinations of section scores that indicate significant potential for invading new ecosystems triggers an Alert designation so that land managers may watch for range expansions. Some plants were categorized as Evaluated But Not Listed because either we lack sufficient information to assign a rating or the available information indicates that the species does not have significant impacts at the present time.

- **High** – These species have severe ecological impacts on physical processes, plant and animal communities, and vegetation structure. Their reproductive biology and other attributes are conducive to moderate to high rates of dispersal and establishment. Most are widely distributed ecologically.
- **Moderate** – These species have substantial and apparent—but generally not severe—ecological impacts on physical processes, plant and animal communities, and vegetation structure. Their reproductive biology and other attributes are conducive to moderate to high rates of dispersal, though establishment is generally dependent upon ecological disturbance. Ecological amplitude and distribution may range from limited to widespread.
- **Limited** – These species are invasive but their ecological impacts are minor on a statewide level or there was not enough information to justify a higher score. Their reproductive biology and other attributes result in low to moderate rates of invasiveness. Ecological amplitude and distribution are generally limited, but these species may be locally persistent and problematic.

The designated purposes of this valuable list:
• Informing the public
• Targeting species for control efforts
• Alerting restorationists to potential problem species
• Aiding those who comment on environmental documents
• Soliciting additional information on exotic plants with unknown or changing status

The CalEPPC list is based on information submitted by their highly trained members and by land managers, botanists and researchers throughout the State of California, and on published sources. The list highlights non-native plants that are serious problems **in wildlands** (natural areas that support native ecosystems, including national, state and local parks, ecological reserves, wildlife areas, national forests, BLM lands, etc.).

List Categories Include:
List A: Most Invasive Wildland Pest Plants; documented as aggressive invaders that displace natives and disrupt natural habitats. Includes two sub-lists; List A-1: Widespread pests that are invasive in more than 3 Jepson regions and List A-2: Regional pests invasive in 3 or fewer Jepson regions.

List B: Wildland Pest Plants of Lesser Invasiveness; invasive pest plants that spread less rapidly and cause a lesser degree of habitat disruption; may be widespread or regional.

Red Alert: Pest plants with potential to spread explosively; infestations are currently small or localized. If found, alert CalEPPC, County Agricultural Commissioner or California Department of Food and Agriculture.

Need More Information: Plants for which current information does not adequately describe the nature of threat to wildlands, distribution or invasiveness. Further information is requested from knowledgeable observers.

Annual Grasses: New in this edition; a preliminary list of annual grasses, abundant and widespread in California that pose significant threats to wildlands. Information is requested to support further definition of this category in next List edition.

Considered But Not Listed: Plants that, after review of status, do not appear to pose a significant threat to wildlands.

Plants that fall into the following categories are not included in the List:
• Plants found mainly or solely in disturbed areas, such as roadsides and agricultural fields.
• Plants that are established only sparingly, with minimal impact on natural habitats.

The CalEPPC list is updated regularly. Please use the form provided on their website to send comments, suggestions or new information to:
Peter W Warner ,
555 Magnolia Avenue,
Petaluma, CA, 94952-2080,
or via email at **peterjwar peterjwarner@ner@earthlink.net**

List A-1: Most Invasive Wildland Pest Plants; Widespread

Latin Name	Common Name	Habitats of Concern and Other Comments	Distribution
Ammophila arenaria	European beach grass	Coastal dunes	SCo,CCo,NCo
Arundo donax	giant reed, arundo	Riparian areas	cSNF,CCo,SCo, SnGb,D,GV
Bromus tectorum	cheat grass, downy brome	Sagebrush, pinyon-juniper, other desert communities; increases fire frequency	GB,D
Carpobrotus edulis	iceplant, sea fig	Many coastal communities, esp. dunes	SCo, CCo, NCo, SnFrB
Centaurea solstitialis[C]	yellow starthistle	Grasslands	CA-FP (uncommon in SoCal)
Cortaderia jubata	Andean pampas grass	Horticultural; many coastal habitats, esp. disturbed or jubatagrass exposed sites incl. logged areas	NCo,NCoRO SnFrB, CCo, WTR,SCo
Cortaderia selloana	pampas grass	Horticultural; coastal dunes, coastal scrub, Monterey pine forest, riparian, grasslands; wetlands in ScV; also on serpentine	SnFrB,SCo, CCo,ScV
Cynara cardunculus[B]	artichoke thistle	Coastal grasslands	CA-FP, esp. CCo,SCo
Cytisus scoparius[C]	Scotch broom	Horticultural; coastal scrub, oak woodlands, Sierra foothills	NW,CaRF,SNF, GV, SCo,CW
Eucalyptus globulus	Tasmanian blue gum	Riparian areas, grasslands, moist slopes -	NCoRO,GV,SnFrB, CCo,SCoRO,SCo, nChI
Foeniculum vulgare	wild fennel	Grasslands; esp. SoCal, Channel Is.; the cultivated garden herb is not invasive	CA-FP
Genista monspessulana[C]	French broom	Horticultural; coastal scrub, oak woodlands, grasslands	NCoRO,NCoRI, SnFrB,CCo, SCoRO,sChI,WTR, PR
Lepidium latifolium[B]	perennial pepperweed,	tall whitetop grasslands – Coastal, inland marshes, riparian areas, wetlands, potential to invade montane wetlands	CA (except KR,D)
Myriophyllum spicatum	Eurasian watermilfoil	Horticultural; lakes, ponds, streams, aquaculture	SnFrB,SnJV, SNH(?); prob. CA
Pennisetum setaceum	fountain grass	Horticultural; grasslands, dunes, desert canyons; roadsides	Deltaic GV,CCo, SCo, SnFrB
Rubus discolor	Himalayan blackberry	Riparian areas, marshes, oak woodlands	CA-FP

Senecio mikanioides	Cape ivy, German ivy	Coastal, riparian areas, also SoCal (south side San Gabriel Mtns.)	SCo,CCo, NCo,SnFrB,SW (=Delairea odorata)
Taeniatherum caput-medusae[C]	medusa-head	Grasslands, particularly alkaline and poorly drained areas	NCoR,CaR, SNF,GV,SCo
Tamarix chinensis, T. gallica, T. parviflora & T. ramosissima	tamarisk, salt cedar	Desert washes, riparian areas, seeps and springs	SCo,D,SnFrB,GV, sNCoR, sSNF, Teh,SCoRI,SNE, WTR
Ulex europaeus[B]	gorse	North, central coastal scrub, grasslands	NCo,NCoRO,CaRF, n&cSNF,SnFrB, CCo

Legend

F: Federal Noxious Weed, as designated by the USDA; targeted for federally-funded prevention, eradication or containment efforts.
A: CA Dept. of Food & Agriculture, on .A. list of Noxious Weeds; agency policies call for eradication, containment or entry refusal.
B: CA Dept. of Food & Agriculture, on .B. list of Noxious Weeds; includes species that are more widespread, and therefore more difficult to
contain; agency allows county Agricultural Commissioners to decide if local eradication or containment is warranted.
C: CA Dept. of Food & Agriculture, on .C. list of Noxious Weeds; includes weeds that are so widespread that the agency does not endorse
state or county-funded eradication or containment efforts except in nurseries or seed lots.
Q: CA Dept. of Food & Agricultures designation for temporary .A. rating pending determination of a permanent rating.
For most species nomenclature follows The Jepson Manual: Higher Plants of California (Hickman, J., Ed., 1993).

Distribution Regions - Distribution by geographic subdivisions per the Jepson Manual

CA=California
CA-FP=California Floristic Province
CaR=Cascade Ranges
CaRF=Cascade Range Foothills
CCo=Central Coast
ChI=Channel Islands
CW=Central Western CA
D=Deserts
DMoj=Mojave Desert
DSon=Sonoran Desert
GB=Great Basin
GV=Great Valley
KR=Klamath Ranges
MP=Modoc Plateau
NCo=North Coast
NCoRI=Inner NCo Ranges
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SW=Southwestern CA
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List A-2 Most Invasive Wildland Pest Plants; Regional

Latin Name	Common Name	Habitats of Concern and Other Comments	Distribution
Ailanthus altissima	tree of heaven	Riparian areas, grasslands, oak woodlands, FP	esp. GV, SCo CA-
Atriplex semibaccata	Australian saltbush	SoCal, coastal grasslands, scrub, high marsh. of coastal salt marshes	CA (except CaR,c&sSN)
Brassica tournefortii	Moroccan or African Mustard	Washes, alkaline flats, disturbed areas in Sonoran Desert	SW,D
Bromus madritensis ssp. rubens	red brome	Widespread; contributing to SoCal scrub, desert scrub type conversions; increases fire frequency	CA
Cardaria draba[B]	white-top, hoary cress	Riparian areas, marshes of central coast; also ag. lands, disturbed areas	Problem only in CCo
Conicosia pugioniformis	narrow-leaved iceplant, roundleaf iceplant -	Coastal dunes, sandy soils near coast; best documented in San Luis Obispo and Santa Barbara cos.	CCo
Cotoneaster pannosus, C. lacteus	cotoneaster	Horticultural; many coastal communities; North Coast, Big Sur; related species also invasive	CCo,SnFrB,NW
Cytisus striatus	striated broom	Often confused with C. scoparius; coastal scrub, grassland	SnFrB,CCo, SCo,PR
Egeria densa	Brazilian waterweed	Streams, ponds, sloughs, lakes; Sacramento-San Joaquin Delta	n&sSNF,SnJV, SnFrB,SnJt,SNE
Ehrharta calycina	veldt grass	Sandy soils, esp. dunes; rapidly spreading on central coast	CCo,SCoRO,WTR
Eichhornia crassipes	water hyacinth	Horticultural; established in natural waterways, esp. troublesome in Sacramento-San Joaquin Delta -	GV,SnFrB,SCo,PR
Elaeagnus angustifolia	Russian olive	Horticultural; interior riparian areas	SnJV,SnFrB, SNE, DMoj
Euphorbia esula[A]	leafy spurge	Rangelands in far no. CA, also reported from Los Angeles Co.-	eKR, NCo, CaR, MP,SCo
Ficus carica	edible fig	Horticultural; Central Valley, foot-hill, South Coast and Channel Is. riparian woodlands-	nSNF,GV,SnFrB, SCo
Lupinus arboreus	bush lupine	Native to SCo, CCo; invasive only in North Coast dunes -	SCo,CCo,NCo
Mentha pulegium	pennyroyal	Santa Rosa Plain (Sonoma Co.) and Central Valley vernal pools; wetlands elsewhere -	NW,GV,CW,SCo

Myoporum laetum	myoporum	Horticultural; coastal riparian areas in SCo	SCo,CCo
Saponaria officinalis	bouncing bet	Horticultural; meadows, riparian habitat in SNE, esp. Mono Basin	NW,CaRH,nSNF, SnFrB, SCoRO,SCo, PR,MP,SNE, GV
Spartina alterniflora	Atlantic or smooth cordgrass -	S.F. Bay salt marshes; populations in Humboldt Bay believed extirpated	CCo(shores of S.F. Bay)

Legend

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SNH=High SN
SnFrB=San Francisco Bay Area
SnGb=San Gabriel Mtns
SW=Southwestern CA
Teh=Tehachapi Mtns
WTR=Western Transverse Ranges

List B: Wildland Pest Plants of Lesser Invasiveness

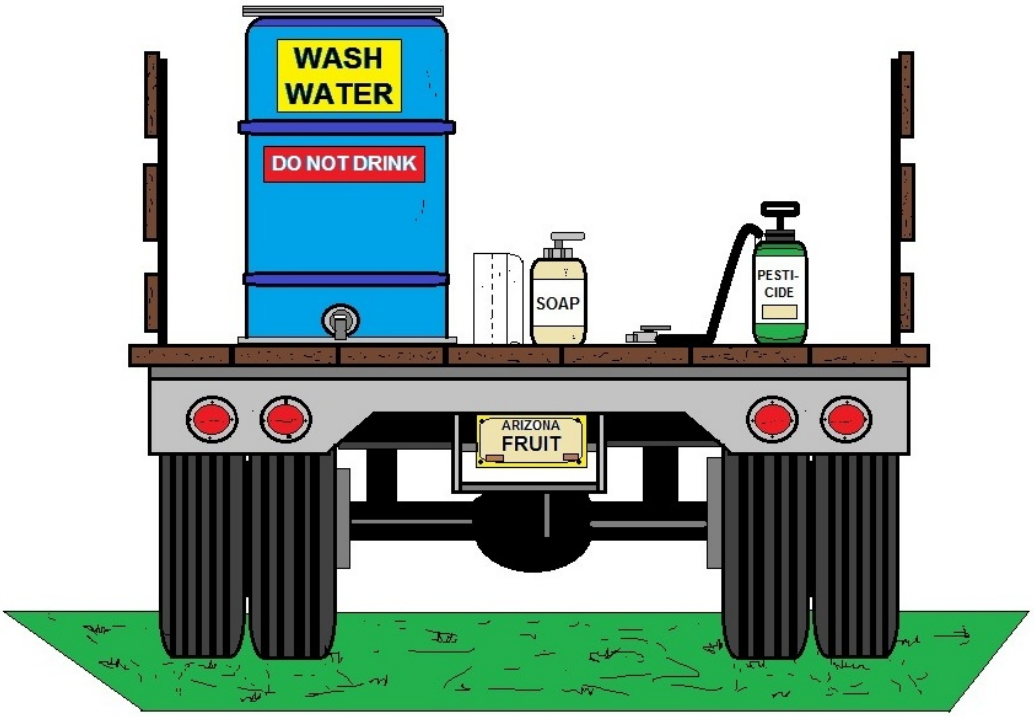
Latin Name	Common Name	Habitats of Concern and Other Comments	Distribution
Ageratina adenophora[F]	eupatory	Horticultural; coastal canyons, coastal scrub, slopes, Marin to San Diego Co; San Gabriel Mtns.	CCo,SnFrB,SCo, SCoRO
Bassia hyssopifolia NW,SNH)	bassia	Alkaline habitats	CA (except
Bellardia trixago SnFrB	bellardia	Grasslands, on serpentine, where a threat to rare natives-	NCoRO, CCo,
Brassica nigra	black mustard	Coastal communities, esp. fog-belt grasslands; disturbed areas	CA-FP
Cardaria chalepensis[B]	lens-podded white-top	Wetlands of Central Valley	CA
Carduus pycnocephalus[C]	Italian thistle	Grasslands, shrublands, oak woodlands	sNCo,sNCoR, SNF, CW, SCo,ScV
Centaurea calcitrapa[B]	purple starthistle	Grasslands	NW,sCaRF,SNF, GV,CW,SW
Centaurea melitensis	tocalote, Malta starthistle	Widespread; sometimes mis-identified as C. solstitialis; perhaps a more serious invader than currently recognized	CA-FP,D
Cirsium arvense[B]	Canada thistle	Especially troublesome in riparian areas	CA-FP
Cirsium vulgare	bull thistle	Riparian areas, marshes, meadows	CA-FP,GB
Conium maculatum	poison hemlock	Mainly disturbed areas but may invade wildlands; known to poison wildlife; early expanding stage in many areas, esp. San Diego Co. riparian, oak understory -	CA-FP
Crataegus monogyna	hawthorn	Horticultural; recent invader, colonizing healthy native forest around Crystal Springs reservoir on S.F. peninsula	SnFrB,CCo,NCo, NCoR
Ehrharta erecta	veldt grass	Wetlands, moist wildlands; common in urban areas; potential to spread rapidly in coastal, riparian, grassland habitats	SnFrB,CCo,SCo
Erechtites glomerata, E. minima SCoRO	Australian fireweed	Coastal woodlands, scrub, NW forests, esp. redwoods	NCo,NCoRO, CCo,SnFrB,
Festuca arundinacea	tall fescue	Horticultural (turf grass); coastal scrub, grasslands in NCo, CCo	CA-FP

Hedera helix	English ivy	Horticultural; invasive in coastal forests, riparian areas	CA-FP
Holcus lanatus	velvet grass	Coastal grasslands, wetlands in No. CA	CA exc. DSon
Hypericum perforatum[C]	Klamathweed, St. John's wort -	Redwood forests, meadows, woodlands; invasion may occur due to lag in control by established biocontrol agents	NW,CaRH,n&cSN, ScV, CCo,SnFrB,PR
Ilex aquifolium	English holly	Horticultural; coastal forests, riparian areas	NCoRO,SnFrB, CCo
Iris pseudacorus	yellow water iris, yellow flag-	Horticultural; riparian, wetland areas, esp. San Diego, Los Angeles cos.	SnFrB,CCo,sSnJV, SCo
Leucanthemum vulgare n&cSNH,	ox-eye daisy	Horticultural; invades grassland,	KR, NCoRO,
		coastal scrub	SnFrB, WTR, PR
Mesembryanthemum crystallinum	crystalline iceplant	Coastal bluffs, dunes, scrub, grasslands; concentrates salt in soil	NCo, CCo, SCo, ChI
Myriophyllum aquaticum	parrot's feather	Horticultural; streams, lakes, ponds	NCo,CaRF,CW, SCo
Olea europaea	olive	Horticultural and agricultural; reported as invasive in riparian habitats in Santa Barbara, San Diego	NCoR,NCoRO,CCo, SnFrB,SCoRO,SCo
Phalaris aquatica	Harding grass	Coastal sites, esp. moist soils	NW,cSNF,CCo,SCo
Potamogeton crispus	curlyleaf pondweed	Scattered distribution in ponds, lakes, streams	NCoR,GV,CCo,SnFrB, SCo,ChI,SnGb, SnBr,DMoj
Ricinus communis	castor bean	SoCal coastal riparian habitats	GV,SCo,CCo
Robinia pseudoacacia	black locust	Horticultural; riparian areas, canyons; native to eastern U.S.	CA-FP,GB
Schinus molle	Peruvian pepper tree	Horticultural; invasive in riparian habitats in San Diego, Santa Cruz Is.	SNF,GV,CW,SW,Teh
Schinus terebinthifolius	Brazilian pepper	Horticultural; riparian areas	sSCo
Senecio jacobaea[B]	tansy ragwort	Grasslands; biocontrol agents established	NCo,wKR, s&wCaR, nSNF, nScV,SW
Spartium junceum	Spanish broom	Coastal scrub, grassland, wetlands, oak woodland, NW forests, esp. redwoods; also roadcuts	NCoRO,ScV,SnFrB, SCoRO,SCo,sChI, WTR
Verbascum thapsus	woolly or common mullein	SNE meadows, sagebrush, pinyon-juniper woodlands; shores of Boggs Lake (Lake Co.)	CA
Vinca major	periwinkle	Horticultural; riparian, oak woodland, other coastal habitats -	NCoRO,SnFrB, CCo, sSCoRO,SCo

Red Alert: Species with potential to spread explosively; infestations currently restricted

Latin Name[1]	Common Name	Habitats of Concern and Other Comments	Distribution[2]
Alhagi pseudalhagi[A]	camel thorn	Noxious weed of arid areas; most infestations in California have been eradicated -	GV,sSNE,D
Arctotheca calendula[A]	Capeweed	Seed-producing types are the problem; most are vegetative only	NCo,SnFrB,CCo
Centaurea maculosa[A]	spotted knapweed	Riparian, grassland, wet meadows, forest habitats; contact CA Food & Ag if new occurrences found	CaR,SN,nScV,nCW, MP,nSNE,sPR,NW
Crupina vulgaris[F,A]	bearded creeper, common crupina -	Aggressively moving into wildlands, esp. grassland habitats	NCoR (Sonoma Co.),MP
Halogeton glomeratus[A]	halogeton	Noxious weed of Great Basin rangelands; report locations to CA Food & Ag; goal is exclusion from CA-	GB
Helichrysum petiolare	licorice plant	North coastal scrub; one population on Mt. Tamalpais, w. Marin Co.-	Not in Jepson
Hydrilla verticillata[F,A]	hydrilla	Noxious water weed; report locations to CA Food & Ag; eradication program in place; found in Clear Lake(Lake Co.) in 1994	NCoRI,n&cSNF, ScV,SCo,D
Lythrum salicaria[B]	purple loosestrife	Horticultural; noxious weed of wetlands, riparian areas	sNCo,NCoRO,nSNF, ScV, SnFrB,nwMP
Ononis alopecuroides[Q]	foxtail restharrow	Eradication efforts underway in San Luis Obispo Co.; to be CCo; looked for elsewhere in CA	not in Jepson
Retama monosperma	bridal broom	First noted at Fallbrook Naval Weapons Station, San Diego Co; San Diego Co.; could rival other invasive brooms -	not in Jepson
Salvinia molesta[F]	giant waterfern	Ponds, lakes, reservoirs, canals – Napa, Sonoma cos., lower Colorado River	not in Jepson
Sapium sebiferum	Chinese tallow tree	Horticultural; riparian, wetland habitats, open areas and understory	ScV,SnFrB; not in Jepson
Sesbania punicea	scarlet wisteria tree	Horticultural; riparian areas; American River Parkway, Sacramento Co., Suisun Marsh, San Joaquin River Parkway	ScV,SnJV; not in Jepson
Spartina anglica	cord grass	Scattered in S.F. Bay	Not in Jepson

Spartina densiflora	dense-flowered cord grass	Scattered in S.F. Bay, Humboldt Bay salt marshes -	CCo,NCo
Spartina patens	salt-meadow cord grass	One site in S.F. Bay, also Siuslaw Estuary, OR and Puget Sound, WA	CCo



ALWAYS PROVIDE ENOUGH WATER TO DECONTAMINATION

Detailed California Invasive Information Section

Latin Name[1]	Common Name	Habitats of Concern and Other Comments	Distribution[2]
Acacia dealbata	silver wattle	Aggressive in natural areas?	SnFRB,SCoRO, SCoRI,CCo
Acacia decurrens	green wattle	Sometimes confused with A. dealbata; aggressive in natural areas? -	Unknown
Acacia melanoxylon	blackwood acacia	Reported from S.F. Bay area, central coast, Santa Cruz Is.; spreads slowly; other areas?	SnFrB,SCoRO, SCo,CCo
Aeschynomene rudis[B]	rough jointvetch	Princeton area, Colusa Co.; pest of rice crops; potential threat to riparian, wetland habitats?	ScV
Agrostis avenacea	Pacific bentgrass	Invading vernal pools in San Diego area; attempts at manual eradication unsuccessful so far; problem in other areas?	sNCo,sNCoR,SNF, GV,CW,nSCo
Aptenia cordifolia	red apple	Habitats where invasive?	CCo,SCo,sChI
Asphodelus fistulosus	asphodel	Common in SCo highway rights-of-way, other disturbed sites; threats to wildlands?	sSnJV,SCo
Carduus acanthoides[A]	giant plumeless thistle	Threatens wildlands?	NCoRI,nSN,SnFrB, nSCoRO,MP
Cistus ladanifer	gum cistus	Horticultural; invades coastal sage scrub, chaparral; areas where problematic? -	sCCo,SnGb
Cordyline australis	New Zealand cabbage	Infestation at Salt Point State Park; bird-dispersed; other problem areas?	Not in Jepson
Cotoneaster spp. (exc. C. pannosus, C. lacteus)	Cotoneaster	Horticultural; bird-distributed; which species are problems in wildlands?	Unknown
Cupressus macrocarpa	Monterey cypress	Native only to Monterey Peninsula; planted and naturalized threat to wildlands? -	CCo, NCo;
Descurainia Sophia	flixweed, tansy mustard	Entering Mojave wildlands through washes; threat to wildlands? -	CA
Dimorphotheca sinuate	African daisy, Cape marigold -	Horticultural; reported as invasive in w. Riverside Co., Ventura Co.; problem elsewhere?	SnJV,SCoRO,SCo PR
Echium candicans,	pride of Madeira,	Horticultural; riparian, grassland,	CCo,SnFrB,SCo,sNCo
E. pininana -	pride of Teneriffe -	coastal scrub communities; spreads by seed -	

Ehrharta longiflora	veldt grass	Reported from San Diego	Not in Jepson
Erica lusitanica	heath	Threat to wildlands?	NCo (Humboldt Co.)
Euphorbia lathyris	caper spurge, gopher plant	Invades coastal scrub, marshes, dunes; Sonoma, Marin cos.; threat to wildlands?	NCo,CCo,GV,SCo
Gazania linearis	gazania	Horticultural; invades grassland in S.F., coastal scrub?	CCo,SCo
Glyceria declinata	Although reported from Central Valley vernal pools, genetic research is needed to confirm identity; plants that have been called G. declinata key in Jepson to native G. occidentalis - Uncertain; not in Jepson		
Hedera canariensis	Algerian ivy	Horticultural; invasive in riparian areas in SoCal?	Not in Jepson
Hirschfeldia incana	Mediterranean or short-pod mustard	Increasing in western, southern Mojave; threat to wildlands?	NCo,SNF,GV,CW, SCo, DMoj
Hypericum canariense	Canary Island hypericum	Reported in San Diego area, coastal sage scrub, grassland; threat to wildlands?	SCo
Hypochaeris radicata	rough cat's-ear	Widespread in coastal grasslands, wetlands; threat to wildlands?	NW,CaRF,nSNF, ScV, CW,SCo
Isatis tinctoria[B]	dyers' woad	Well-known invader in Utah; threat to wildlands?	KR,CaR,nSNH, MP
Ligustrum lucidum	glossy privet	Horticultural; spreading rapidly on Mendocino coast; problem in other areas?	NCo; not in Jepson
Limonium ramosissimum ssp. provinciale	sea lavender	Reported spreading in Carpinteria Salt Marsh; problem in other areas?	Not in Jepson
Ludwigia uruguayensis (= L. hexapetala)	water primrose	Invasive in aquatic habitats; non-native status questioned?	NCo,sNCoRO,CCo, SnFrB,SCo
Malephora crocea	ice plant	Invades margins of wetlands, bluffs along SCo	CCo,SCo,sChI
Maytenus boaria	mayten	Horticultural; scattered in riparian forests,	ScV; east SnFrB ScV, SnFrB
Mesembryanthemum nodiflorum	slender-leaved iceplant	Abundant on Channel Islands; invades wetlands; habitats where problematic?	SnFrB,SCo,ChI
Nicotiana glauca	tree tobacco	Disturbed places; not very competitive with natives in coastal scrub, chaparral; spreading along Putah Creek (Yolo Co.); problems elsewhere?	NCoRI,c&sSNF,GV, CW,SW,D
Oxalis pes-caprae	Bermuda buttercup	Invades disturbed sites; invasive in undisturbed habitats?	NCo,NCoRO,CCo, SnFrB,SCoRO,SCo
Parentucellia viscose		Threat to NCo (Humboldt Co.) dune swales? -	NCo,NCoRO,CCo,SCo

Passiflora caerulea		Horticultural; reported from SoCal; threat to wildlands? -	SCo; not in Jepson
Pennisetum clandestinum[F,C] - -	Kikuyu grass	Disturbed sites, roadsides; threat to wildlands? -	NCo,CCo,SnFrB,SCo, Santa Cruz Is.
Phyla nodiflora	mat lippia	Most varieties in CA are native; taxonomy unclear; status of plants in vernal pools, wetlands?	NW(except GV,CCo,SnFrB,SCo, KR,NCoRH), PR,DSon
inus radiata cultivars	Monterey pine	Cultivars invading native Monterey, Cambria forests, where spread of pine pitch canker is a concern -	CCo
Piptatherum miliaceum	smilo grass	Aggressive in SoCal creeks, canyons; threats to wildlands?	NCo,GV,CW,SCo
Pistacia chinensis	Chinese pistache	Horticultural; invades riparian areas and woodlands in ScV -	ScV
Prunus cerasifera	cherry plum	Oak woodland, riparian areas; esp. Marin, Sonoma cos.; bird-distributed; problems elsewhere?	SnFrB,CCo
Pyracantha angustifolia	pyracantha	Horticultural; spreads from seed in S.F. Bay area; bird-distributed; problem elsewhere?	sNCoRO,CCo,SnFrB, SCo
Salsola soda	glasswort	Threat to salt marshes?	nCCo,SnFrB
Salsola tragus[C]	Russian thistle, tumbleweed -	Abundant in dry open areas in w. Mojave Desert, Great Basin; not limited to disturbed sites; threats?	CA
Salvia aethiopis[B]	Mediterranean sage	Creates monocultures in E. Oregon grasslands; threat to CA wildlands?-	MP
Stipa capensis		Distribution and threats?	Not in Jepson
Tamarix aphylla	athel	Spreading in Salton Sea area; threats to wildlands? -	nSnJV,nSCo,D
Tanacetum vulgare	common tansy	Jepson reports as uncommon, escape from cultivation in urban areas; problem in wildlands?	SCoRO, NCo, NCoRO,CaRH
Verbena bonariensis, V. litoralis - -	tall vervain	Horticultural; invades riparian forests,wetlands; extensive along ScV riparian corridors; roadsides (Yuba Co.); elsewhere? -	ScV,nSnJV, nSnFrB,CCo

Annual Grasses

Latin Name[1]	Common Name	Habitats of Concern and Other Comments	Distribution[2]
Aegilops triuncialis[B] n&cSNF,	barbed goatgrass	Serpentine soils, grasslands	sNCoR,CaRF, ScV,nCW
Avena barbata	slender wild oat	Lower elev. in SoCal; coastal slopes, coastal sage scrub, disturbed sites -	CA-FP,MP,DMoj
Avena fatua	wild oat	Lower elev. in SoCal; coastal slopes, coastal sage scrub on deeper soil, disturbed sites -	CA-FP,MP,DMoj
Brachypodium distachyon - -	false brome	Expanding in SoCal; common in Orange Co. -	sNCoR,sCaRF, SNF, GV,CW,SCo,sChI
Bromus diandrus	ripgut brome	Coastal dunes, coastal sage scrub, grasslands -	CA
Lolium multiflorum	Italian ryegrass	Wetland areas, esp. vernal pools in San Diego Co.; common in disturbed sites -	CA-FP
Schismus arabicus	Mediterranean grass	Threat to Mojave and Colorado desert shrublands? -	SnJV,CW,sChI,D
Schismus barbatus	Mediterranean grass	Threat to Mojave and Colorado desert shrublands? -	SnJV,SW,D

Considered Plants, but not yet listed.

Latin Name[1]	Common Name	Habitats of Concern and Other Comments
Albizia lophantha	plume acacia	Not invasive
Anthoxanthum odoratum	sweet vernal grass	Disturbed sites on coast; Marin, Sonoma, Mendocino cos.
Carpobrotus chilensis	sea fig	Native status in question; not a threat to wildlands
Centranthus	ruber red valerian	Horticultural; roadcuts in Marin Co.; not a threat to wildlands
Convolvulus arvensis[C]	field bindweed	Disturbed sites; ag lands
Coprosma repens	mirror plant	No evidence of wildland threat
Crocosmia x Crocosmiiflo		Generally in disturbed coastal, urban areas, roadsides
Digitalis purpurea	foxglove	Horticultural; scattered in prairies, meadows, disturbed sites; not a major wildland threat
Dipsacus sativus, D. fullonum -	wild teasel, Fuller.s teasel	Roadsides, disturbed sites
Fumaria officinalis, F. parviflora	fumitory	S.F. Bay area, Monterey Bay salt marshes, sandy disturbed sites
Medicago polymorpha	California bur clover	Grasslands, moist sites; mainly restricted to disturbed sites
Melilotus officinalis	yellow sweet clover	Restricted to disturbed sites in CA
Nerium oleander	oleander	Horticultural; not invasive, although reported from. riparian areas in Central Valley, San Bernardino Mtns
Picris echioides	bristly ox-tongue	Disturbed areas
Silybum marianum	milk thistle	Disturbed areas, especially overgrazed moist pasturelands; may interfere with restoration
Xanthium spinosum	spiny cocklebur	Identified as native in The Jepson Manual (Hickman, 1993) and A California Flora (Munz and Keck, 1968); restricted to disturbed areas
Zantedeschia aethiopica	calla lily	Horticultural; mainly a garden escape in wet coastal areas
Zoysia cultivars	Amazoy and others	Horticultural; no evidence of wildland threat

ALWAYS WEAR PPE WHEN HANDLING PESTICIDES

2017 Changes to EPA's Worker Protection Standard

In late 2015 the Environmental Protection Agency issued the long awaited revision to the Worker Protection Standard (WPS). Although it is now technically active it will not be enforced until 2017 but the original WPS will still be enforced until the end of 2016. Please keep in mind that the WPS covers both restricted use AND general use pesticides.

This course contains EPA's federal rule requirements. Please be aware that each state implements pesticide regulations that may be more stringent than EPA's regulations and these frequently are changed. Check with your state environmental/pesticide agency for more information.

Federal Weed Rule 7 CFR 360.100 Definitions.

(a) As used in this part, words in the singular form shall be deemed to import the plural and vice versa, as the case may require.
(b) As used in this part, the terms as defined in section 3 of the Act (7 U.S.C. 2802) shall apply with equal force and effect. In addition and except as may be provided otherwise in this part the following words shall be construed, respectively, to mean:

Department. The U.S. Department of Agriculture.
Deputy Administrator. The Deputy Administrator of the Plant Protection and Quarantine Programs of the Animal and Plant Health Inspection Service of the Department, or any other officer or employee of the Plant Protection and Quarantine Programs to whom authority has heretofore been delegated or may hereafter be delegated to act in his stead.

Plant Protection and Quarantine Programs. The Plant Protection and Quarantine Programs, Animal and Plant Health Inspection Service of the Department. [41 FR 49988, Nov. 12, 1976]

360.200 Designation of noxious weeds.
{1} One or more common names of weeds are given in parentheses after most scientific names to help identify the weeds represented by such scientific names; however, a scientific name is intended to include all weeds within the genus or species represented by the scientific name, regardless of whether the common name or names are as comprehensive in scope as the scientific name.

Pursuant to the provisions of section 10 of the Federal Noxious Weed Act of 1974 (7 U.S.C. 2809) the Secretary of Agriculture, after publication of the required notice of proposal and after public hearing on the proposal when requested by any interested person, has determined based upon the information received at any such hearing and other information available to the Secretary, that the following plants are within the definition of a ``noxious weed'' in section 3(c) of the Act (7 U.S.C. 2802(c)) and that their dissemination in the United States may reasonably be expected to have, to a serious degree, an effect specified in said section 3(c) of the Act:

(a) Aquatic weeds

Azolla pinnata R. Brown (mosquito fern, water velvet)
Eichornia azurea (Swartz) Kunth (anchored waterhyacinth, rooted waterhyacinth)
Hydrilla verticillata (Linnaeus f.) Royle (hydrilla)
Hygrophila polysperma T. Anderson (Miramar weed)
Ipomoea aquatica Forsskal (water-spinach, swamp morning-glory)
Lagarosiphon major (Ridley) Moss
Limnophila sessiliflora (Vahl) Blume (ambulia)
Melaleuca quenquinervia (Cav.) Blake (broadleaf paper bark tree).
Monochoria hastata (Linnaeus) Solms-Laubach
Monochoria vaginalis (Burman f.) C. Presl
+Ottelia alismoides (L.) Pers.
Sagittaria sagittifolia Linnaeus (arrowhead)
Salvinia auriculata Aublet (giant salvinia)
Salvinia biloba Raddi (giant salvinia)
Salvinia herzogii de la Sota (giant salvinia)
Salvinia molesta D.S. Mitchell (giant salvinia)
Sparganium erectum Linnaeus (exotic bur-reed)

(b) Parasitic weeds:

Aeginetia spp.
Alectra spp.
Cuscuta spp. (dodders), other than following species:
Cuscuta americana Linnaeus
Cuscuta applanata Engelmann
Cuscuta approximata Babington
Cuscuta attenuata Waterfall
Cuscuta boldinghii Urban
Cuscuta brachycalyx (Yuncker) Yuncker
Cuscuta californica Hooker & Arnott
Cuscuta campestris Yuncker
Cuscuta cassytoides Nees ex Engelmann
Cuscuta ceanothii Behr
Cuscuta cephalanthii Engelmann
Cuscuta compacta Jussieu
Cuscuta corylii Engelmann
Cuscuta cuspidata Engelmann
Cuscuta decipiens Yuncker
Cuscuta dentatasquamata Yuncker
Cuscuta denticulata Engelmann
Cuscuta epilinum Weihe
Cuscuta epithymum (Linnaeus) Linnaeus
Cuscuta erosa Yuncker
Cuscuta europaea Linnaeus
Cuscuta exalta Engelmann
Cuscuta fasciculata Yuncker
Cuscuta glabrior (Engelmann) Yuncker
Cuscuta globulosa Bentham
Cuscuta glomerata Choisy
Cuscuta gronovii Willdenow
Cuscuta harperi Small
Cuscuta howelliana Rubtzoff
Cuscuta indecora Choisy
Cuscuta jepsonii Yuncker
Cuscuta leptantha Engelmann
Cuscuta mitriformis Engelmann
Cuscuta nevadensis I. M. Johnston
Cuscuta obtusiflora Humboldt, Bonpland, & Kunth
Cuscuta occidentalis Millspaugh ex Mill & Nuttall
Cuscuta odontolepis Engelmann
Cuscuta pentagona Engelmann
Cuscuta planiflora Tenore
Cuscuta plattensis A. Nelson
Cuscuta polygonorum Engelmann
Cuscuta rostrata Shuttleworth ex Engelmann
Cuscuta runyonii Yuncker
Cuscuta salina Engelmann
Cuscuta sandwichiana Choisy
Cuscuta squamata Engelmann
Cuscuta suaveolens Seringe
Cuscuta suksdorfii Yuncker
Cuscuta tuberculata Brandegee
Cuscuta umbellata Humboldt, Bonpland, & Kunth
Cuscuta umbrosa Beyrich ex Hooker

Field Dodder
Parasitizing red clover. The plant has a yellowish coloration and a spaghetti-string appearance.

Field Dodder
Parasitizing field bindweed.

Cuscuta vetchii Brandegee
Cuscuta warneri Yuncker
Orobanche spp. (broomrapes), other than the following species:
Orobanche bulbosa (Gray) G. Beck
Orobanche californica Schlechtendal & Chamisso
Orobanche cooperi (Gray) Heller
Orobanche corymbosa (Rydberg) Ferris
Orobanche dugesii (S. Watson) Munz
Orobanche fasciculata Nuttall
Orobanche ludoviciana Nuttall
Orobanche multicaulis Brandegee
Orobanche parishii (Jepson) Heckard
Orobanche pinorum Geyer ex Hooker
Orobanche uniflora Linnaeus
Orobanche valida Jepson
Orobanche vallicola (Jepson) Heckard
Striga spp. (witchweeds)

(c) Terrestrial weeds:

Ageratina adenophora (Sprengel) King & Robinson (crofton weed)
Alternanthera sessilis (Linnaeus) R. Brown ex de Candolle (sessile joyweed)
Asphodelus fistulosus Linnaeus (onionweed)
Avena sterilis Linnaeus (including Avena ludoviciana Durieu) (animated oat, wild oat)
Borreria alata (Aublet) de Candolle
Carthamus oxyacantha M. Bieberstein (wild safflower)
Chrysopogon aciculatus (Retzius) Trinius (pilipiliula)
Commelina benghalensis Linnaeus (Benghal dayflower)
Crupina vulgaris Cassini (common crupina)
Digitaria scalarum (Schweinfurth) Chiovenda (African couchgrass, fingergrass)
Digitaria velutina (Forsskal) Palisot de Beauvois (velvet fingergrass, annual conchgrass)
Drymaria arenarioides Humboldt & Bonpland ex Roemer & Schultes (lightning weed)
Emex australis Steinheil (three-cornered jack)
Emex spinosa (Linnaeus) Campdera (devil's thorn)
Galega officinalis Linnaeus (goatsrue)
Heracleum mantegazzianum Sommier & Levier (giant hogweed)
Imperata brasiliensis Trinius (Brazilian satintail)
Imperata cylindrica (Linnaeus) Raeuschel (cogongrass)
Ipomoea triloba Linnaeus (little bell, aiea morning-glory)
Ischaemum rugosum Salisbury (murainograss)
Leptochloa chinensis (Linnaeus) Nees (Asian sprangletop)
Lycium ferocissimum Miers (African boxthorn)
Melastoma malabathricum Linnaeus
Mikania cordata (Burman f.) B. L. Robinson (mile-a-minute)
Mikania micrantha Humboldt, Bonpland, & Kunth
Mimosa invisa Martius (giant sensitive plant)
Mimosa pigra Linneaus var. pigra (catclaw mimosa)
Nassella trichotoma (Nees) Hackel ex Arechavaleta (serrated tussock)
Opuntia aurantiaca Lindley (jointed prickly pear)
Oryza longistaminata A. Chevalier & Roehrich (red rice)
Oryza punctata Kotschy ex Steudel (red rice)
Oryza rufipogon Griffith (red rice)
Paspalum scrobiculatum Linnaeus (Kodo-millet)
Pennisetum clandestinum Hochstetter ex Chiovenda (kikuyugrass)
Pennisetum macrourum Trinius (African feathergrass)
Pennisetum pedicellatum Trinius (kyasumagrass)

Pennisetum polystachion (Linnaeus) Schultes (missiongrass, thin napiergrass)
Prosopis alpataco R. A. Philippi
Prosopis argentina Burkart
Prosopis articulata S. Watson
Prosopis burkartii Munoz
Prosopis caldenia Burkart
Prosopis calingastana Burkart
Prosopis campestris Griseback
Prosopis castellanosii Burkart
Prosopis denudans Bentham
Prosopis elata (Burkart) Burkart
Prosopis farcta (Solander ex Russell) Macbride
Prosopis ferox Grisebach
Prosopis fiebrigii Harms
Prosopis hassleri Harms
Prosopis humilis Gillies ex Hooker & Arnott
Prosopis kuntzei Harms
Prosopis pallida (Humboldt & Bonpland ex Willdenow) Humboldt, Bonpland, & Kunth
Prosopis palmeri S. Watson
Prosopis reptans Bentham var. reptans
Prosopis rojasiana Burkart
Prosopis ruizlealii Burkart
Prosopis ruscifolia Grisebach
Prosopis sericantha Gillies ex Hooker & Arnott
Prosopis strombulifera (Lamarck) Bentham
Prosopis torquata (Cavanilles ex Lagasca y Segura) de Candolle
Rottboellia exaltata Linnaeus f. (itchgrass, raoulgrass)
Rubus fruticosus Linnaeus (complex) (wild blackberry)
Rubus moluccanus Linnaeus (wild raspberry)
Saccharum spontaneum Linnaeus (wild sugarcane)
Salsola vermiculata Linnaeus (wormleaf salsola)
Setaria pallide-fusca (Schumacher) Stapf & Hubbard (cattail grass)
Solanum torvum Swartz (turkeyberry)
+Solanum viarum Dunal (tropical soda apple)
Tridax procumbens Linnaeus (coat buttons)
Urochloa panicoides Beauvois (liverseed grass)

Introduced, Invasive, and Noxious Plants

NRCS Invasive Species Policy
Invasive Species Executive Order 13112

Federal Noxious Weeds

112 records returned

Click on an accepted name below to view its PLANTS Profile with more information, and web links if available. Noxious weeds that are synonyms retain their noxious status, and are indented beneath the current PLANTS accepted name.

USDA, Animal and Plant Health Inspection Service (APHIS), Plant Protection and Quarantine (PPQ). *State Plant Regulatory Officials letters* (). National Plant Board.

USDA, Animal and Plant Health Inspection Service (APHIS), Plant Protection and Quarantine (PPQ). 2012. *Federal noxious weed list* (1 February 2012). USDA, APHIS, PPQ.

Symbol	Scientific Name	Noxious Common Name	Federal Noxious Status†	Native Status*
AEGIN	*Aeginetia* L.		NW	
AGAD2	*Ageratina adenophora* (Spreng.) R.M. King & H. Rob.	crofton weed	NW	L48 (I), HI (I)
ALECT2	*Alectra* Thunb.		NW	
ALSE4	*Alternanthera sessilis* (L.) R. Br. ex DC.	sessile joyweed	NW	L48 (I), HI (I), PR (N), VI (N)
ASFI2	*Asphodelus fistulosus* L.	onionweed	NW	L48 (I)
AVST	*Avena sterilis* L.	animated oat	NW	L48 (I), CAN (W)
AZPI	*Azolla pinnata* R. Br.	mosquito fern	NW	L48 (I)
CAOX6	*Carthamus oxyacanthus* M. Bieb.			L48 (I)
CAOX2	*Carthamus oxyacantha* M. Bieb., orth. var.	wild safflower	NW	
CATA5	*Caulerpa taxifolia* (Vahl) C. Agardh[1]		NW	L48 (I)
CHAC	*Chrysopogon aciculatus* (Retz.) Trin.	pilipiliula	NW	HI (I)
COBE2	*Commelina benghalensis* L.	Benghal dayflower	NW	L48 (I), HI (I), PR (I)
CRVU2	*Crupina vulgaris* Cass.	common crupina	NW	L48 (I)
CUSCU	*Cuscuta* L.[2]	dodder	NW	
DIAB	*Digitaria abyssinica* (Hochst. ex A. Rich.) Stapf			HI (I)
DISC5	*Digitaria scalarum* (Schweinf.) Chiov.	African couch grass	NW	
DIVE2	*Digitaria velutina* (Forssk.) P. Beauv.	velvet fingergrass	NW	L48 (I)
DRAR7	*Drymaria arenarioides* Humb. & Bonpl. ex Schult. [excluded]	alfombrilla	NW	
EIAZ2	*Eichhornia azurea* (Sw.) Kunth	anchored waterhyacinth	NW	L48 (I), PR (I)
EMAU	*Emex australis* Steinh.	three-cornered jack	NW	L48 (I)
EMSP	*Emex spinosa* (L.) Campd.	devil's thorn	NW	L48 (I), HI (I)
GAOF	*Galega officinalis* L.	goatsrue	NW	L48 (I), CAN (I)

HEMA17	*Heracleum mantegazzianum* Sommier & Levier	giant hogweed	NW	L48 (I), CAN (I)
HYVE3	*Hydrilla verticillata* (L. f.) Royle	hydrilla	NW	L48 (I)
HYPO3	*Hygrophila polysperma* (Roxb.) T. Anderson	Miramar weed	NW	L48 (I)
IMBR	*Imperata brasiliensis* Trin.	Brazilian satintail	NW	L48 (I), PR (I)
IMCY	*Imperata cylindrica* (L.) P. Beauv.	cogongrass	NW	L48 (I)
IPAQ	*Ipomoea aquatica* Forssk.	Chinese waterspinach	NW	L48 (I), HI (I), PR (I)
ISRU	*Ischaemum rugosum* Salisb.	murain-grass	NW	L48 (I)
LAMA15	*Lagarosiphon major* (Ridley) Moss	oxygen weed	NW	
LECH2	*Leptochloa chinensis* (L.) Nees [excluded]	Asian sprangletop	NW	
LISE3	*Limnophila sessiliflora* (Vahl) Blume	ambulia	NW	L48 (I)
LYFE4	*Lycium ferocissimum* Miers			L48 (I)
LYFE3	*Lycium ferrocissimum* Miers, orth. var.	African boxthorn	NW	
LYFL7	*Lygodium flexuosum* (L.) Sw.	maidenhair creeper	NW	
MEQU	*Melaleuca quinquenervia* (Cav.) S.F. Blake	melaleuca	NW	L48 (I), HI (I), PR (I)
MEMA	*Melastoma malabathricum* L.		NW	HI (I)
MICO16	*Mikania cordata* (Burm. f.) B.L. Rob. [excluded]	mile-a-minute	NW	
MIMI5	*Mikania micrantha* Kunth	mile-a-minute	NW	L48 (I), PR (N)
MIDI8	*Mimosa diplotricha* C. Wright			HI (I), PR (I)
MIIN80	*Mimosa invisa* Mart., non Mart. ex Colla	giant sensitive plant	NW	
MIPE2	*Mimosa pellita* Kunth ex Willd.			L48 (N), PR (N)
MIPI	*Mimosa pigra* auct. non L.	catclaw mimosa	NW	
MOHA2	*Monochoria hastata* (L.) Solms [excluded]	monochoria	NW	
MOVA	*Monochoria vaginalis* (Burm. f.) C. Presl ex Kunth	pickerel weed	NW	L48 (I), HI (I)
MOCO8	*Moraea collina* Thunb.	Cape tulip	NW	L48 (I)
MOFL2	*Moraea flaccida* (Sweet) Steud.	Cape tulip	NW	
MOMI4	*Moraea miniata* Andrews		NW	
MOOC2	*Moraea ochroleuca* (Salisb.) Drapiez		NW	
MOPA8	*Moraea pallida* (Baker) Goldblatt		NW	
NATR3	*Nassella trichotoma* (Nees) Hack.	serrated tussock	NW	L48 (I)
ONAC2	*Onopordum acaulon* L.		NW	
ONIL	*Onopordum illyricum* L.		NW	L48 (I)
OPAU10	*Opuntia aurantiaca* Lindl.	jointed prickly pear	NW	
OROBA	*Orobanche* L.[2]	broomrape	NW	
ORLO3	*Oryza longistaminata* A. Chev. & Roehr.	red rice	NW	
ORPU13	*Oryza punctata* Kotzchy ex Steud.	red rice	NW	
ORRU	*Oryza rufipogon* Griffiths	red rice	NW	L48 (I)
OTAL	*Ottelia alismoides* (L.) Pers.	duck-lettuce	NW	L48 (I)
PASC6	*Paspalum scrobiculatum* L.	Kodo-millet	NW	(I), L48 (I), HI (I)
PECL2	*Pennisetum clandestinum* Hochst. ex Chiov.	kikuyugrass	NW	L48 (I), HI (I), PR (I), VI (I)

PEMA80	*Pennisetum macrourum* Trin.	African feathergrass	NW	L48 (I), HI (I)
PEPE24	*Pennisetum pedicellatum* Trin.	kyasuma-grass	NW	L48 (I)
PEPO14	*Pennisetum polystachion* (L.) Schult.			(I), L48 (I), HI (I), PR (I)
PEPO4	*Pennisetum polystachyon* (L.) Schult., orth. var.	missiongrass	NW	
PRAL11	*Prosopis alpataco* Phil.	mesquite	NW	
PRAR6	*Prosopis argentina* Burkart	mesquite	NW	
PRBU2	*Prosopis burkartii* Muñoz	mesquite	NW	
PRCA9	*Prosopis caldenia* Burkart	mesquite	NW	
PRCA10	*Prosopis calingastana* Burkart	mesquite	NW	
PRCA11	*Prosopis campestris* Griseb.	mesquite	NW	
PRCA12	*Prosopis castellanosii* Burkart	mesquite	NW	
PRDE4	*Prosopis denudans* Benth.	mesquite	NW	
PREL5	*Prosopis elata* (Burkart) Burkart	mesquite	NW	
PRFA2	*Prosopis farcta* (Banks & Sol.) J.F. Macbr.	Syrian mesquite	NW	L48 (I)
PRFE2	*Prosopis ferox* Griseb.	mesquite	NW	
PRFI4	*Prosopis fiebrigii* Harms	mesquite	NW	
PRHA4	*Prosopis hassleri* Harms ex Hassler	mesquite	NW	
PRHU3	*Prosopis humilis* Gillies ex Hook. & Arn.	mesquite	NW	
PRKU2	*Prosopis kuntzei* Harms ex Hassler	mesquite	NW	
PRPA4	*Prosopis pallida* (Humb. & Bonpl. ex Willd.) Kunth	kiawe	NW	(I), HI (I), PR (I), VI (I)
PRPA10	*Prosopis palmeri* S. Watson	mesquite	NW	
PRRE2	*Prosopis reptans* Benth.	tornillo	NW	L48 (N)
PRRO4	*Prosopis rojasiana* Burkart	mesquite	NW	
PRRU4	*Prosopis ruizlealii* Burkart	mesquite	NW	
PRRU5	*Prosopis ruscifolia* Griseb.	mesquite	NW	
PRSE5	*Prosopis sericantha* Gillies ex Hook. & Arn.	mesquite	NW	
PRST3	*Prosopis strombulifera* (Lam.) Benth.	Argentine screwbean	NW	L48 (I)
PRTO3	*Prosopis torquata* DC.	mesquite	NW	
PRVE	*Prosopis velutina* Woot.			L48 (N), HI (I)
PRAR4	*Prosopis articulata* S. Watson	velvet mesquite	NW	
ROCO6	*Rottboellia cochinchinensis* (Lour.) W.D. Clayton	itchgrass	NW	L48 (I), PR (I)
RUFR80	*Rubus fruticosus* L. [excluded]	wild blackberry complex	NW	
RUMO4	*Rubus moluccanus* L. [excluded]	wild blackberry	NW	
SASP	*Saccharum spontaneum* L.	wild sugarcane	NW	HI (I), PR (I)
SASA7	*Sagittaria sagittifolia* L. [excluded]	arrowhead	NW	
SAVE6	*Salsola vermiculata* L.	wormleaf salsola	NW	L48 (I)
SAAU	*Salvinia auriculata* Aubl.	giant salvinia	NW	PR (I)
SABI9	*Salvinia biloba* Raddi	giant salvinia	NW	
SAHE7	*Salvinia herzogii* de la Sota	giant salvinia	NW	
SAMO5	*Salvinia molesta* Mitchell	giant salvinia	NW	L48 (I), HI (I)

SEIN10	*Senecio inaequidens* DC.	South African ragwort	NW	
SEPUP3	*Setaria pumila* (Poir.) Roem. & Schult. ssp. *pallidefusca* (Schumach.) B.K. Simon			L48 (I)
SEPA82	*Setaria pallidifusca* (Schumach.) Stapf & C.E. Hubbard, orth. var.	cattail grass	NW	
SOTA3	*Solanum tampicense* Dunal	wetland nightshade	NW	L48 (I)
SOTO4	*Solanum torvum* Sw.	turkeyberry	NW	L48 (I), HI (I), PR (I), VI (I)
SOVI2	*Solanum viarum* Dunal	tropical soda apple	NW	L48 (I)
SPER	*Sparganium erectum* L.	exotic bur-reed	NW	L48 (N)
SPAL3	*Spermacoce alata* Aubl. [excluded]	borreria	NW	
STRIG	*Striga* Lour.	witchweed	NW, Q	
TRPR5	*Tridax procumbens* L.	coat buttons	NW	(I), L48 (I), HI (I), PR (I), VI (I)
URPA	*Urochloa panicoides* P. Beauv.	liverseed grass	NW	L48 (I)

†Code	Noxious Status
NW	Noxious weed
Q	Quarantine

*Code	Native Status
I	Introduced
N	Native
W	Waif

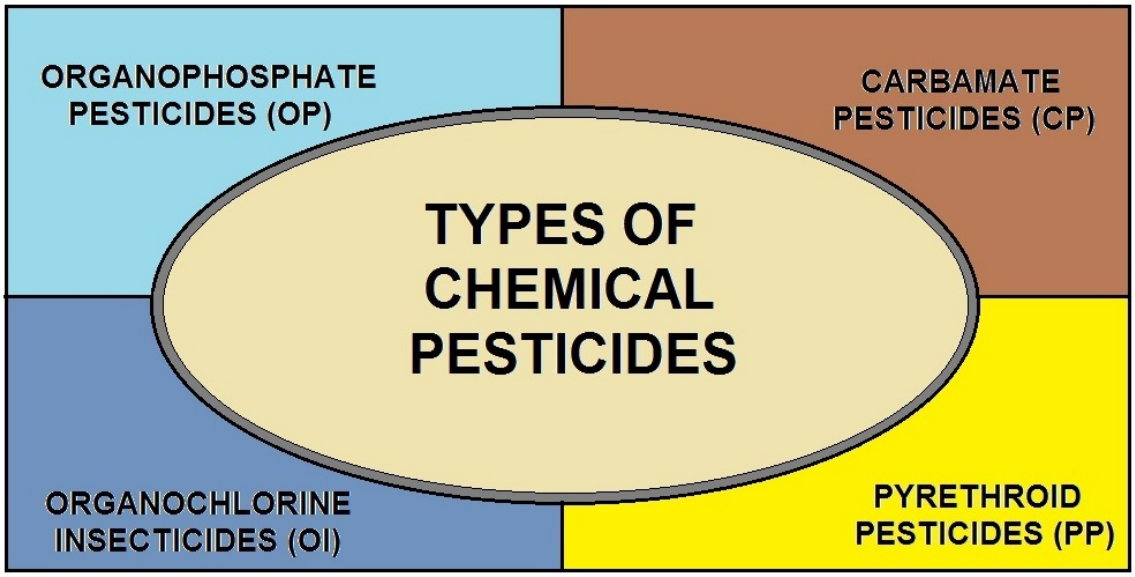
*Code	Native Status Jursdiction
	None
L48	Lower 48 States
HI	Hawaii
PR	Puerto Rico
VI	Virgin Islands
CAN	Canada

1 Mediterranean clone
2 other than native or widely distributed species

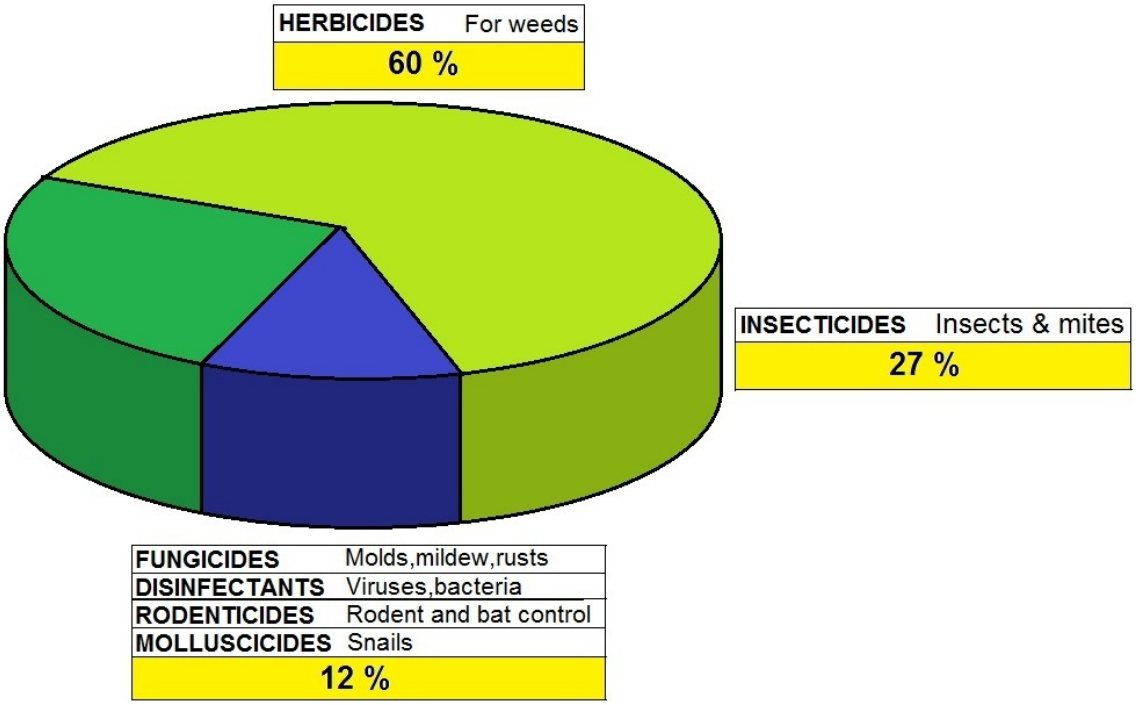
Additional Federal government efforts to understand and control noxious plants can be found at:

- APHIS Federal Noxious Weed List
- APHIS Web: Noxious Weeds Factsheets and Publications
- APHIS-NAPIS Pest Tracker
- Aquatic Nuisance Species Task Force
- Army Corps Noxious & Nuisance Plant Management Information System
- ARS: Exotic & Invasive Weed Research
- BLM: The Weed Hall of Shame
- Defense Environmental Network and Information Exchange (DENIX)
- Executive Order: Federal Effort to Combat Invasive Species (1999)
- Federal Highway Administration
- FHWA Guidance on Invasive Species
- FHWA-The Nature of Roadsides and the Tools to Work With It
- Great Lakes Indian Fish and Wildlife Commission-Exotic Plants
- Invasive Plants Fact Book (FICMNEW)
- InvasiveSpeciesInfo.Gov
- MT-USDA NRCS Management and Ecology of Invasive Plant Species
- NAPPO Phytosanitary Alert System
- National Agricultural Pest Information System (NAPIS)
- Nonnative Invasive Plants of Southern Forests: Identification Guide
- NPCI Alien Plant Working Group
- NPS Invasive Species Management and Control
- Plant Conservation Alliance Alien Plants
- PLANTS Database Home Page
- U.S. National Plant Board
- USDA APHIS Federal Noxious Weed Disseminules of the U.S.
- USDA ARS Invasive Plant Research Laboratory-Florida
- USDA FS Invasive Plants-Northeastern Area
- USDA FS Invasive Plants-Northeastern Area Weeds of the Week
- USDI GS-Southwest Exotic Plant Information Clearinghouse
- USDI NPS Plant Invaders of Mid-Atlantic Natural Areas
- USDI NPS-Priority Weed Species
- USFS Weed Wanted Posters
- USFWS Invasive Species Program
- Western Rangeland Weeds

Arrowhead (*Sagittaria* Spp.)



TYPES OF PESTICIDES



PESTICIDE USE BY TYPE

Federal Pesticide Recordkeeping Requirements

Questions and Answers
Final regulations to implement requirements in section 1491 of the Food, Agriculture, Conservation, and Trade (**FACT**) Act of 1990, commonly referred to as the 1990 Farm Bill, went into effect **May 10, 1993.** On February 10, 1995 amendments to the regulations were published, which became effective on May 11, 1995. The regulations are administered by the U.S. Department of Agriculture's Agricultural Marketing Service (**AMS**).

Why are there regulations for restricted use pesticide recordkeeping for certified private applicators? The FACT Act of 1990, subtitle H, section 1491, states that the Secretary of Agriculture, in consultation with the Administrator of the Environmental Protection Agency (**EPA**), ***"shall require certified applicators of restricted use pesticides..... to maintain records comparable to records maintained by commercial applicators of pesticides in each State."*** Certified applicators include both commercial and private applicators.

The EPA currently requires certified commercial applicators to keep records under regulations implementing the Federal Insecticide, Fungicide, and Rodenticide Act (**FIFRA**). The EPA is prohibited from requiring certified private applicators to maintain records. However, some individual States require certified private applicators to maintain records.

Do the regulations apply to all pesticide applications? No. The regulations only require recordkeeping for applications of federally-restricted use pesticides. Pesticides are classified as restricted use, general use, or for both uses.

Is a Federal form required for maintaining the record(s)? No. The regulations do not require the use of a standardized form. This allows applicators the flexibility to fit the recordkeeping requirements into their current recordkeeping scheme.

What information is a certified private applicator required to maintain on a restricted use pesticide application? The recordkeeping requirements are:

1. The brand or product name, and the EPA registration number of the restricted use pesticide that was applied;
2. The total amount of the restricted use pesticide applied;
3. The location of the application, the size of area treated, and the crop, commodity, stored product, or site to which a restricted use pesticide was applied;
4. The month, day, and year when the restricted use pesticide application occurred; and
5. The name and certification number (if applicable) of the certified applicator who applied or who supervised the application of the restricted use pesticide.

When does the pesticide application information have to be recorded? The information required shall be recorded within 14 days following the pesticide application.

How long are records required to be kept? Restricted use pesticide records must be retained by the applicator for 2 years from the date of application and made available to individuals who are authorized to have access to the record information. Certified applicators have no reporting requirements under the regulations.

Who has authorization to obtain record information from the certified applicator? Individuals representing the Secretary of Agriculture or the State designated agency, which is most commonly the State Department of Agriculture. Also the attending licensed health care professional, or an individual acting under the direction of the attending licensed health care professional, is authorized access to record information when it is determined the information is needed to provide medical treatment or first aid to an individual who may have been exposed to the restricted use pesticide for which the record is maintained.

Are there any penalties for violation of the Federal pesticide recordkeeping requirements?
Yes. Any certified applicator who violates the requirements shall be subject to a civil penalty of not more than $500 in the case of the first offense, and shall be subject to a civil penalty of not less than $1000 for each violation for subsequent offenses, except that the civil penalty shall be less than $1000 if the Administrator determines that the certified applicator made a good faith effort to comply.

AMENDMENTS TO THE REGULATIONS - EFFECTIVE MAY 11, 1995

1. **Change in the way the location of a "spot application" is recorded.**
   A" spot application" is an application(s) of a restricted use pesticide made on the same day in a total area of less than one-tenth of an acre. This provision still does not apply to records maintained for greenhouse and nursery applications.

   The regulations were amended to require a more detailed description of the location of a ***"spot application."*** Spot applications must be recorded with the following information: Brand or product name and EPA registration number; total amount applied; location must be designated as ***"spot application,"*** followed by a concise description of the location (**Examples:** Spot application, noxious weeds were spot sprayed throughout field number 5 and 6. Spot application, sprayed for weeds next to the silo); and month, day, and year of application.

2. **Shortened the time period to make a record of the restricted use pesticide application.**
   The time period was reduced from 30 days to 14 days for the required information to be legibly recorded following the restricted use pesticide application.

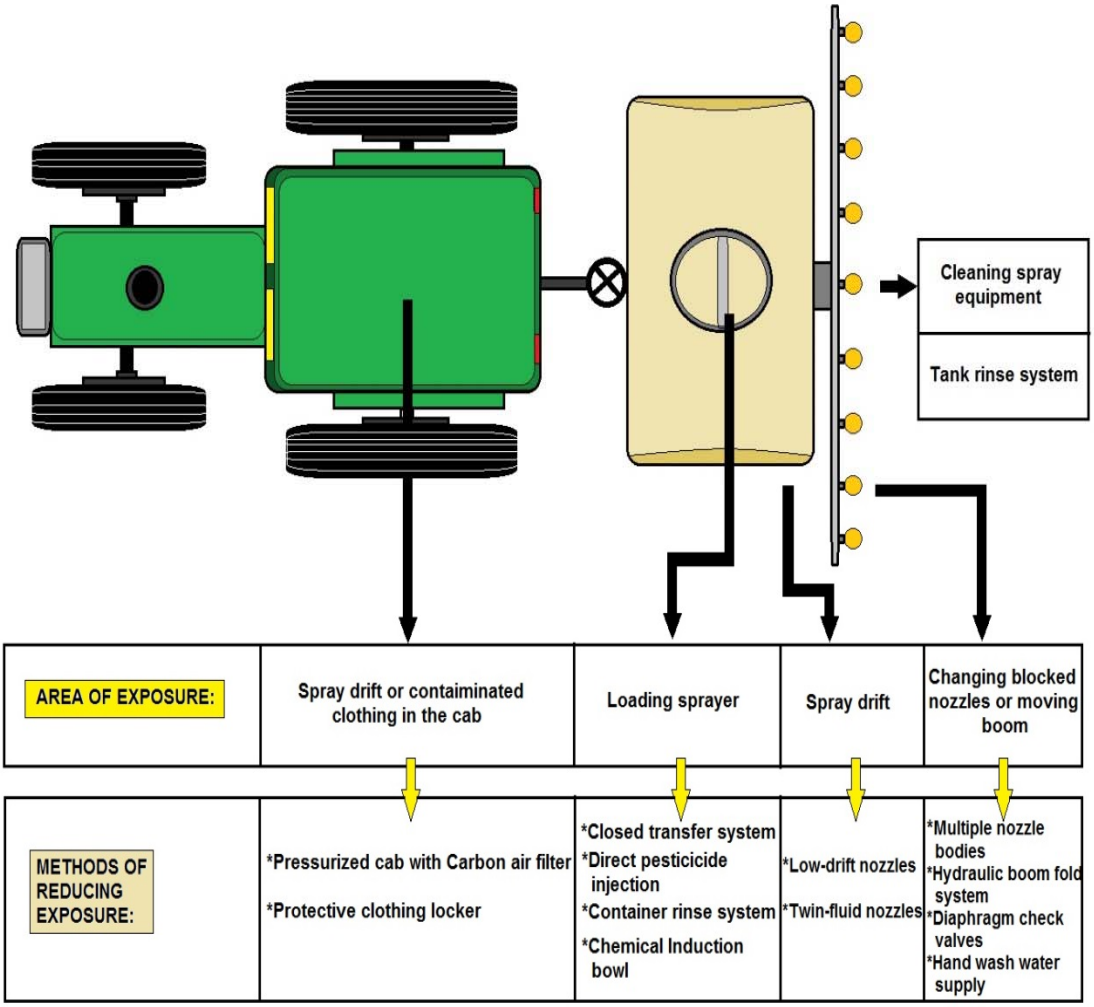
   However, whether or not the written record has been completed, the certified applicator shall provide the record information for medical treatment or first aid.

3. **Change in the definition of a medical emergency.**
   A medical emergency is defined as a situation that requires immediate medical treatment or first aid to treat possible symptoms of pesticide poisoning or exposure.

4. **Change in the definition of a licensed health care professional.**
   A licensed health care professional is defined as a physician, nurse, emergency medical technician, or other qualified individual, licensed or certified by a State to provide medical treatment.

5. **Change in accessing records to facilitate medical treatment.**
   When the attending licensed health care professional, or an individual acting under the direction of the attending licensed health care professional, determines that any record of the application of any restricted use pesticide required to be maintained is necessary to provide medical treatment or first aid to an individual who may have been exposed to the restricted use pesticide for which the record is or will be maintained, the certified applicator required to maintain the record shall promptly provide the record information and any available label information. If it is determined by the attending licensed health care professional, or an individual acting under the direction of the attending licensed health care professional, to be a medical emergency, the record information of the restricted use pesticide, relating to the medical emergency, shall be provided immediately.

6. **Change in provisions for the release of record information obtained for purposes of medical treatment.**
   (1) The attending licensed health care professional, or an individual acting under the direction of the attending licensed health care professional, may utilize and release the record or record information when necessary to provide medical treatment or first aid to an individual who may have been exposed to the ' restricted use pesticide for which the record is or will be maintained;
   (2) the attending licensed health care professional may release the record or record information to appropriate Federal or State agencies that deal with pesticide use or any health issue related to the use of pesticides when necessary to prevent further injury or illness; and
   (3) a licensed health care professional may release the record or record information to submit pesticide poisoning incident reports to the appropriate State or Federal agencies.
7. **Clarification that the Administrator of AMS, has flexibility in assessing civil penalties.**
   The amended regulations provide the Administrator of AMS, or the Administrator's designee, with flexibility in assessing civil penalties.



AGRICULTURAL PESTICIDE EXPOSURE DIAGRAM #1

Spanish warning statements. If the product is classified as toxicity category I or toxicity category II according to the criteria in § 156.10(h)(1), the signal word shall appear in Spanish in addition to English followed by the statement, "Si Usted no entiende la etiqueta, busque a alguien para que se la explique a Usted en detalle. (If you do not understand the label, find someone to explain it to you in detail.)"

The Spanish signal word "PELIGRO" shall be used for products in toxicity category I, and the Spanish signal word "AVISO" shall be used for products in toxicity category II. These statements shall appear on the label close to the English signal word.

Additional Herbicide and Insecticide Rule Safety Precautions

The Federal Environmental Pesticide Control Act of 1972 in part prohibits the application of any pesticide in a manner inconsistent with its labeling. This means that a pesticide cannot be used unless it is registered for the specific pest. Consequently, some chemicals formerly used by homeowners and pesticide applicators can no longer be used legally.

Insecticide labels are subject to change, and changes may have occurred since this publication was printed. County Extension agents and Extension entomologists are notified as these changes occur.

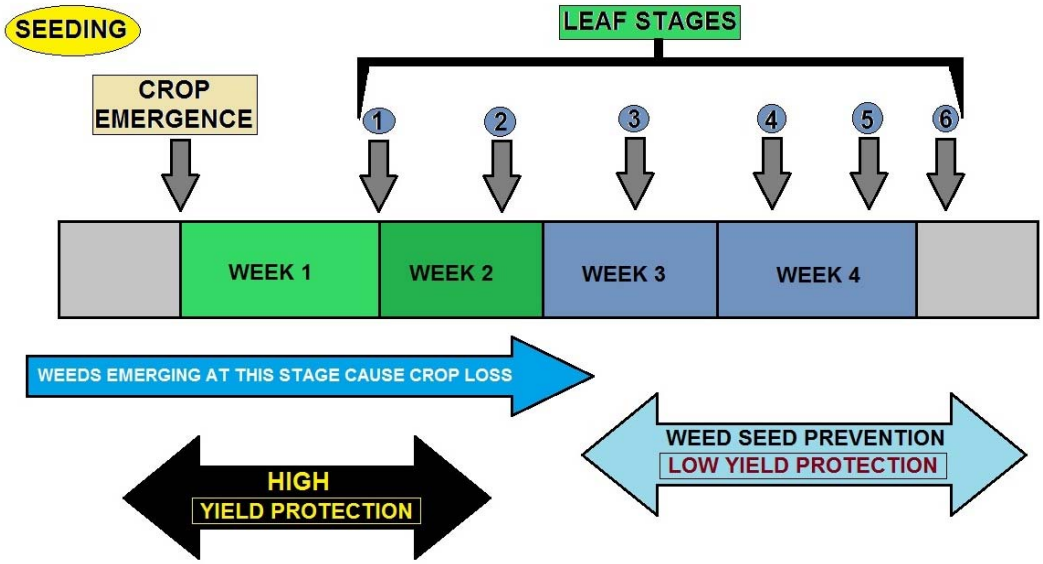
The pesticide **APPLICATOR** is always responsible for the effects of pesticide residues as well as problems caused by residues that drift from the application site to other property. Always read and carefully follow instructions on the product label.

When using pesticides, always avoid prolonged chemical contact with skin. Wash exposed skin areas with generous amounts of soap and water. Launder clothing worn during application in hot water using a phosphate detergent. Do not contaminate food, dishes, utensils or food preparation areas with insecticide. Any contaminated food should be discarded, and dishes and utensils should be thoroughly washed.

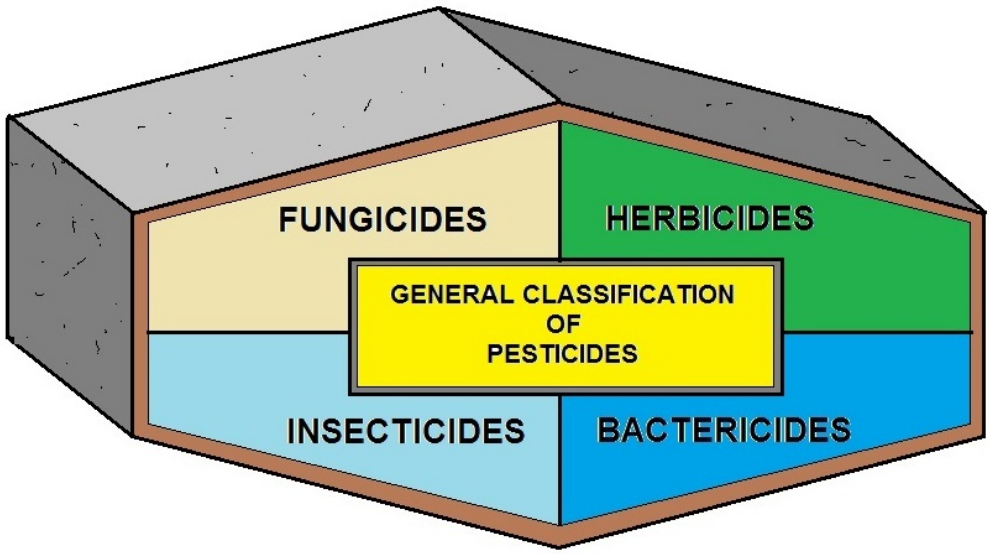
Safety Notes

- **READ, UNDERSTAND** and **FOLLOW** all insecticide label directions and precautions. Some product labels may require that pilot lights should be off on stove, furnace and water heater.
- Keep insecticides in original containers with the label intact. Do not contaminate food, water, dishes or utensils.
- Keep insecticides out of reach of children and do not allow children or pets near treated surfaces until dry.

Purple Loosestrife



WEED CONTROL TIMING DIAGRAM



CLASSIFICATION OF PESTICIDES

Herbicide Hazards

Whether there is herbicide injury to crops depends upon several factors:

- the chemical nature of the herbicide,
- the sensitivity of the plant species,
- the methods of application,
- the proximity of target and non-target crops, and
- the behavior of the herbicide in the environment.

All herbicides can be classified as either selective or nonselective. Selective herbicides kill certain weeds with little or no injury to the crop. It is the difference in plant response that determines the effectiveness of the herbicide and safety to the crop.

Non-selective herbicides are those which will kill or injure virtually all kinds of vegetation. The risk of drift is great when the application is by foliar spray. When the soil is treated, a hazard may arise from the herbicide persisting in the soil longer than intended and interfering with growing a crop at some later time. The movement of a non-selective herbicide by runoff or by soil erosion to non-target areas is another possibility. Typical 2,4 D injury symptoms on grape leaves.

Drift hazards
There are two ways herbicides drift to non-target areas.

1. Mist droplets are generated by the sprayer nozzles. The size of droplet depends upon the nozzle pressure, the size of nozzle orifice and the surface tension of the spray solution.

2. Vapor may be generated depending upon the volatility of the herbicide. The amount of vapor varies with the chemical and the conditions of application.

Droplet Drift
The distance of droplet drift depends upon the size of the droplets, the velocity of the wind and the height above the ground where the herbicide is discharged. In general, larger orifices and lower pressures result in larger droplets. Conversely, the smaller the orifice and the greater the pressure, the smaller will be the size of the droplets. The smaller the droplet, the farther it will drift with wind of any particular velocity.

Vapor Drift
Volatility refers to the ability of a herbicide to vaporize and to mix freely with the air. Volatile herbicides may produce vapors that can be carried great distances from the target area to other crop sites. Such herbicide volatility can also reduce the rate of application to the target area. A row of grapevines severely injured by herbicides used to clear the nearby railroad.

Phenoxy Herbicides
The phenoxy group of herbicides has been most often involved in crop injury by off-target drift. The phenoxy group includes 2,4-D, 2,4,5-T, 2,4-DB, 2,4,5-TP (Silvex) and MCPA. These herbicides are most commonly used for the control of broad-leaved weeds in crops and for the control of undesirable woody species.

Phenoxy herbicides are more or less volatile. Vapors can arise from the herbicide while mixing, during and after application.

Phenoxy herbicides in general are formulated in two ways, as esters or amines. Esters are more effective in controlling hard-to-kill weeds but are the most hazardous in terms of volatility and consequent drift to sensitive crops.

There are two categories of esters: the regular form and the low-volatile form. The latter form is less likely to cause problems. The amine formulations are safer to use than are the esters, but they are less effective in their performance.

Susceptible Crops
Although most kinds of broad-leaved plants are susceptible to injury by phenoxy herbicides, grapes and tomatoes are the most sensitive. Cotton, soybeans, potatoes, other vegetables, legume crops and many ornamental trees, shrubs and flowers can also be severely affected.

Because grapes are one of the crops most sensitive to phenoxy herbicides, these herbicides should not be applied in an area where vineyards are established. Great distances between the site of application and the location of a vineyard, tomato field, melon patch or greenhouse may not afford protection against injury from drift.

Problems of drift are common and often result in hardship for the grower of the susceptible crop, judgments against the applicator for crop losses and a bad reputation for the herbicide. Typical leaf-curl symptoms of soybeans exposed to phenoxy herbicides.

Symptoms of Injury
Mere traces of a phenoxy herbicide may cause sensitive plants to produce abnormally large leaves, exaggerated distances between leaves and multiplied or enlarged flowering or fruiting parts.

Greater concentrations of the herbicide can cause stunting and cupping of leaves, spiraling growth of soft shoots, clearing and enlargement of major leaf veins and severe distortion of flowering or fruiting parts. After severe exposure, leaves may be fan-shaped or severely stunted and curled, with extensive development of small teeth along leaf margins.

When grapes are visibly affected, there will generally be uneven or delayed coloring of the fruit. Reduced production of sugars within the fruit can render the crop worthless. Shoots grow either excessively long or may be stunted, and the canes may lose their ability to survive normal winter temperatures. Leaves exhibit the characteristic fan shape with sawtooth margins.

Affected tomato plants exhibit cupped or elongated leaves with enlarged pale veins and toothy margins. Stem twisting, severe stunting of plants, puffy fruits or abortion of flowers commonly occur.

Soybeans usually exhibit leaf distortion at lowest levels of exposure while higher levels can result in yellowing of foliage and defoliation.

Greenhouse crops, vegetables, ornamental plants and desirable native vegetation are affected in various ways. The leaves and stems of shrubs or trees may become stunted, stretched, twisted or spindly to the extent of being unsightly or worthless.

Long-term Effects
Woody plants such as grapes, apples and peaches which show substantial stem and leaf distortion usually fail to produce a marketable crop. If the symptoms are sudden or severe, one to three years may be required for recovery. Severe cases of phenoxy herbicide injury may result in stunted growth and poor ripening for two to four years after exposure. Growers seeking monetary compensation should be aware of these long-term effects and not be too quick to settle damage claims.

Annual crops of herbaceous plants such as florist crops, field crops and vegetables do not have the same potential for long-term losses. But the value of a single season's crop can constitute a major economic loss to either the grower or the user of the herbicide.

Other Herbicides
Several herbicides other than the phenoxys can also injure sensitive crops. Some of those applied to soils to control woody plants or weeds in crops may be absorbed by the extensive roots of nearby plants such as fruit trees, nut trees and grape vines. Certain non-phenoxy herbicides used to kill woody plants by application to the foliage can cause problems when they drift to economic crops.

Preventing Crop Injury
Awareness is the key to preventing damage by phenoxy and other herbicides. Once applicators are aware of the hazards and possible consequences of misuse they can take several steps to prevent problems:

- ✓ Learn the locations of sensitive crops in the area.
- ✓ Avoid use of ester formulations of phenoxy herbicides in any area near sensitive crops.
- ✓ Use amine forms of phenoxy herbicides to reduce the risk of vapor drifting to nearby sensitive crops.
- ✓ Apply pesticides, especially herbicides, on a calm day or when a light breeze is blowing away from sensitive crops.
- ✓ Spray when temperatures will remain below 90 degrees F to prevent or reduce vaporization.
- ✓ Use sprayer nozzles with larger orifices and operate at lower pump pressures to reduce the production of fine droplets.

Resolving Problems
User responsibility. Registration and labeling of a particular pesticide clearly give individuals the right to apply the pesticide as long as they follow the directions for use and the precautions stated on the label. The use of a pesticide in any way contrary to the label is a violation of federal law. Misuse of a pesticide may make the user liable to either criminal prosecution or to civil proceedings or both.

Although there is no legal obligation for herbicide applicators to take stock of sensitive crops in the area of application and to consult and cooperate with neighbors in matters of herbicide use, it is advisable to do so.

Further information about pesticide use and hazards can be obtained from any University of Missouri Extension Center. Rights of injured parties. Those who grow specialty crops which may be injured as a result of pesticide misuse have rights protected by law. Through civil proceedings, injured parties may attempt to regain financial losses or to secure punitive judgments.

Growers of sensitive crops are not obligated to inform operators of surrounding farms and local industries of the presence and sensitivity of their crops, but it is advisable to seek the cooperation of neighbors in the use of hazardous pesticides. Reporting incidents of pesticide damage. Two governmental agencies may exercise regulatory powers in situations of herbicide misuse.

Spray Pressure
Spray pressure influences the size of droplets formed from the spray solution. The spray solution emerges from the nozzle in a sheet, and droplets form at the edge of the sheet. Increased nozzle pressure causes the sheet to be thinner, and this thinner sheet will break into smaller droplets than from a sheet produced at lower pressure. Also, larger orifice nozzles with high delivery rates produce a thicker sheet of spray solution and larger droplets than smaller nozzles.

Communication
The majority of drift complaints pertain to trees, shrubs and ornamentals. Communicating with non-agricultural rural residents may reduce complaint submissions originating from lack of knowledge of products used and injury symptoms.

Other Components
Flow control devices are necessary to make the tank, pump and nozzles work together. Depending on the application system, these devices may include pressure regulators, unloader valves and control valves. Because both the spray pattern and flow rate are determined by operating pressure, each sprayer should be equipped with a pressure gauge. The gauge should be placed where it may be easily seen. Strainers are also required for effective treatments. Strainers trap particles and debris in the spray mixture and protect the pump, control devices and nozzles from damage.

Dispersal Summary
All nozzles produce a range of droplet sizes. The small, drift-prone particles cannot be eliminated but can be reduced and kept within reasonable limits.

Here are some tips:

- Select low or nonvolatile pesticides.
- Read and follow the pesticide label. Instructions on the pesticide label are given to ensure the safe and effective use of pesticides with minimal risk to the environment. Each pesticide is registered for use on specific sites or locations. Surveys indicate approximately 65 percent of drift complaints involved application procedures in violation of the label.
- Apply a pesticide only if economic thresholds warrant an application.
- Use spray additives within label guidelines. This will increase the droplet sizes and pesticide effectiveness.
- Use larger orifice sizes. This will give larger droplets and will increase the number of tank refills, but will improve coverage and effectiveness.
- Avoid high pressure. High pressure creates finer droplets; 45 PSI should be considered maximum for conventional broadcast spraying.
- Use drift-reduction nozzles. They will produce larger droplets when operated at low pressures.
- Use wide angle nozzles, low boom heights, and keep the boom stable.
- Drift is minimal when wind velocity is less than 10 mph. Do not spray when wind is greater or blowing towards sensitive crops, gardens, dwellings, and livestock or water sources.
- Use shielded booms. When banding, use shroud covers.

Pesticide applicators and others, including landowners, play a very important role in pesticide application -- deciding whether or not to apply a pesticide and if so how best to make that application. It is their responsibility to know and understand a product's use restrictions.

They are responsible for complying with all other pesticide laws regarding pesticide applications and ensuring that their application equipment and techniques will produce a minimum of spray drift. The EPA also expects applicators to exercise a high level of professionalism in making decisions about applications.

Topic 11 Invasive Plant Rule Section
Post Quiz Answers at the rear of Glossary

Fill-in-the-blank

1. Invasion can be thought of as a process that in our example, a plant must go through to become a successful, yet harmful invader. Several barriers must be overcome for a plant to be considered an invasive weed. Invasive weeds are _____.

Survival barriers

2. The second set of obstacles that _____must overcome is barriers to germination and survival in its new location. These typically are environmental barriers such as adequate moisture availability to allow successful germination and survival of seedlings that will continue to grow to maturity. Other physical barriers might be soil pH, nutrient availability, or competition for resources from neighboring plants.

Dispersal and spread barriers

3. Established non-native plants must overcome barriers to dispersal and spread from their site of establishment to be considered_____. Additionally, the rate of spread must be relatively fast. However, this movement or spread alone does not necessarily make this non-native plant an invasive weed or invasive species.

Harm and impact

4. Finally, a plant is deemed to be invasive if it causes negative environmental, economic, or human health effects, which outweigh any beneficial effects. For example, yellow starthistle is a source of nectar for bee producers. But the displacement of native and other _____caused by yellow starthistle leads to dramatically decreased forage for wildlife and livestock, which severely disrupts the profitability of associated businesses. These negative effects greatly overshadow the positive effects and thus, define harm caused by yellow starthistle and explain why it is considered an invasive species.

Herbicide and Insecticide Safety Precautions

5. The _____in part prohibits the application of any pesticide in a manner inconsistent with its labeling. This means that a pesticide cannot be used unless it is registered for the specific pest. Consequently, some chemicals formerly used by homeowners and pesticide applicators can no longer be used legally.

6. The pesticide **APPLICATOR** is always _____as well as problems caused by residues that drift from the application site to other property. Always read and carefully follow instructions on the product label.

7. When using pesticides, always avoid_____. Wash exposed skin areas with generous amounts of soap and water. Launder clothing worn during application in hot water using a phosphate detergent. Do not contaminate food, dishes, utensils or food preparation areas with insecticide. Any contaminated food should be discarded, and dishes and utensils should be thoroughly washed.

Droplet Drift

8. The distance of droplet drift depends upon the size of the droplets, the _____and the height above the ground where the herbicide is discharged. In general, larger orifices and lower pressures result in larger droplets. Conversely, the smaller the orifice and the greater the pressure, the smaller will be the size of the droplets. The smaller the droplet, the farther it will drift with wind of any particular velocity.

Vapor Drift

9. Volatility refers to the ability of a herbicide to vaporize and to mix freely with the air. Volatile herbicides may produce vapors that can be carried great distances from the target area to other crop sites. Such herbicide volatility can also reduce the_____. A row of grapevines severely injured by herbicides used to clear the nearby railroad.

Phenoxy Herbicides

10. The phenoxy group of herbicides has been most often involved in crop injury by off-target drift. The phenoxy group includes 2,4-D, 2,4,5-T, 2,4-DB, 2,4,5-TP (Silvex) and MCPA. These herbicides are most commonly used for the control of _____and for the control of undesirable woody species.

Weed and Plant Glossary

Abaxial – a. (L. *ab*, from; *axis*, axle) that surface of any structure which is remote or turned away from the axis, such as the lower surface of a leaf.
Absorption - The process by which a filter media traps unwanted molecules.
Acaulescent - a. (Gr. *a*, without; *kaulos*, stalk) having no stem or seemingly without a stem.
Accessory flower parts - Sepal and petal organs found on flowers. The sepals and petals are not essential for pollination, but may aid in attracting insects or other organisms.
Achene - n. (Gr. *a*, not; *chainein*, to gape) any small, dry fruit with one seed whose outer covering (pericarp) does not burst when ripe.
Acicular - a. (L. *acicula*, a small needle) slender and pointed; needle-like with a sharp point.
Acidic - Water with a pH of less than 7.
Acropetal - a. (Gr. *akros*, summit; L. *petere*, to seek) developing upward from the base toward the apex.
Acrylic - A plastic material used to construct fish tanks, filters and accessories.
Actinomorphic - a. (Gr. *aktis*, ray; *morphe*, form) descriptive of a flower or set of flower parts which can be cut through the center into equal and similar parts along two or more planes; having radial symmetry.
Aculeus - n. (L. *aculeus*, prickle) a prickle growing from bark. pl. aculei**.**
Acumen - n. (L. *acumen*, a point, a sting) the point of an acuminate leaf.
Acuminate - a. drawn out into a long point; tapering point.
Acute - a. (L. *acutus*, sharpened) sharp at the end; ending in a sharp point.
Adaxial - a. (L. *ad*, to; *axis*, axle) pertaining to the side of an organ toward the axis, such as the upper surface of a leaf.
Adipose Fin - A small fin located behind the dorsal fin and in front of the caudal fin.
Adnate - a. (L. *adnatus*, to be born, to grow to) fusion of unlike structures or parts.
Adsorption - The process by which filter media attracts unwanted molecules to its surface via a chemical charge.
Adventitious - a. (L. *adventitius*, extraneous) plant structures or tissue occurring in an abnormal position.
Adventitious plant - Able to exist either on land or in the water.
Adventitious root - Root which develops from the node of a stem or similar organ, such as a Rhizome, Stolan or runner.
Adventive - a. (L. *advenire*, to arrive) a plant that is not native to the environment.
Aerenchyma - n. (Gr. *aer*, air; *enchyma*, an infusion) parenchyma tissue with large and abundant intercellular air spaces; air-storing tissue; resembles the tissue of cork.
Aerobic - An organism that needs oxygen to survive.
Aggregate - a. (L. *ad*, to; *gregare*, to collect into a flock) crowded into a cluster; a number of separate fruits from a single flower aggregated together; an aggregate flower is formed by a cluster of carples.
Airstone - A device that attaches to the air pump to create various bubble effects.
Alimentary canal - The tube of the digestive system through which food passes; where digestion takes place.
Alkaline - Water with a pH between 7 and 14. Also known as Basic.
Allele - n. (Gr. *allelon*, one another) one of a pair or more of alternative hereditary characters; a gene which can occupy the same locus as another gene in a particular chromosome.
Allelochemicals - compounds that have an allelopathic effect.
Allelopathy - n. (Gr. *allelon*, one another; *pathos*, suffering) the influence or effect of one living plant upon another; refers to biochemical interaction between all types of plants and its effect depends on a chemical compound being added to the environment.
Alternate - a. (L. *alteratus*, one after another) said of leaves occurring one at a node; said also of members of adjacent whorls in the flower when any member of one whorl is in front of or behind the junction of two adjacent members of the succeeding whorl.
Alternation of generations - the occurrence in one life history of two or more different forms differently produced, usually an alternation of a sexual with an asexual form.
Alveola - n. (L. *alveolus*, small cavity) a pit on the surface of an organ.
Alveolate - a. (L. *alveolatus*, pitted) deeply pitted so as to resemble a honeycomb, as are the surfaces of some seeds or achenes.
Ammonia (NH3) - A dissolved gas that even in low concentrations is toxic to fish. It is produced by the breakdown of organic waste products.
Anaerobic - A term used to describe an organism that lives in an environment with little or no oxygen.
Anaerobiosis - n. (L. Gr. *an*, without; *aer*, air; *biosis*, manner of life) life in the absence of air or free oxygen; anaerobic respiration, respiration occurring in the absence of oxygen.
Anal fin - Single fin mounted vertically below the fish.
Anastomosis - n. (Gr. *ana*, up to; *stoma*, mouth) connecting by cross-veins and forming a network.

Anatomy - n. (LL. *anatomia*, dissection) the branch of morphology that deals with the structure of plants, esp. the internal structure as revealed by the microscope.
Androecium - n. (Gr. *andros*, man; *oikos*, house) male reproductive organs of a plant; a collective term applied to all structures of the stamen whorl or whorls.
Androgynal - a. (Gr. *andros*, man; *gonos*, woman) bearing staminate and pistillate flowers on the same parent stem.
Androgynous - staminate flowers above the pistillate flowers in the same inflorescence.
Androphore - n. (Gr. *aner*, man; *phoros*, carrying) a support or column, formed by fusion of filaments, on which the stamens are borne.
Anemophily - n. (Gr. *anemos*, wind; *philein*, to love) pollination by wind.
Angiospermae - n. (Gr. *anggeion*, vessel; *sperma*, seed) a major division of the plant kingdom, commonly called flowering plants (as their reproductive organs are in flowers,) having seeds which develop in a closed ovary made of carpels, a very reduced gametophyte, and endosperm develop from a triple fusion nucleus. pl. Angiosperms.
Annual - a. (L. *annualis*, yearly, from *annus*, year) a plant which completes its life history within a year.
Anoxia - n. (L. *an*, not; and oxygen) lack of oxygen or not enough oxygen.
Anther - n. (Gr. *antheros*, flowery, from *anthein*, to bloom) the top of the stamen, usually elevated by means of a filament, which contains the pollen.
Anthesis - n. (Gr. *anthesis*, bloom, from *anthein*, to bloom) stage or period during which the flower bud is fully open; flowering.
Antrorse - a. (L. *ante*, before; *vertere*, to turn) forward or upward.
Apetalous - a. (Gr. *a*, without; *petalon*, leaf) having flowers without petals; having no corolla.
Apical - a. (L. *apex*, the tip or top of a thing) at the tip or summit.
Apical bud - The principal growing point of the stem.
Apiculate - a. (LL. *apiculatus*, point) terminated abruptly by a small, distinct point, an apiculus or apicule.
Apocarpous - a. (Gr. *apo*, away; *karpos*, fruit) having separate carpels.
Apomixis - n. (Gr. *apo*, away; *mixis*, a mixing) in general, reproducing without sexual reproduction; often used to denote seed production without a sexual process having been involved.
Appressed - a., adv. (L. *ad*, to; *pressare*, to press) lying flat or close against something. Often used for hairs.
Aquatic plants - plants that must grow in water whether rooted in the mud or floating without anchorage; plants that must complete part or all of their life cycle in or near the water.
Aquatic vascular plants - aquatic plants containing the conductive vascular tissue, phloem and xylem.
Arachnoid - a. (Gr. *arachme*, spider, cobweb; *eidos*) like a cobweb; covered with or consisting of soft fibers or hairs so entangled as to give a cobwebby appearance.
Arcuate - a. (L. *arcuatus*, pp. of *arcuare*, to arch, bend like a bow, from arcus, a bow) bent or curved in the form of a bow.
Aril - n. (Fr. *arrile*, Sp. *arillo*, L. *arilli*, dried grapes, from *aridus*, dry) an additional covering that forms on some seeds after fertilization, and developing from the stalk of the ovule.
Aristate - a. (L. *arista*, awn) awned; having an awn.
Articulate - a. (L. *articulatus*, jointed, pp. of *articulare*, to join) having joints; jointed; provided with places where separation may take place.
Ascending - v. (Fr. *scandere*, to climb) rising or curving upward.
Asepalous - a. (Gr. *a*, without; L. *pelatum*, petal) without sepals.
Asexual reproduction - Any form of reproduction that does not require the union of male and female reproductive material.
Attenuate - a. (L. *attenuare*, to thin) gradually narrowed to a long point at apex or base.
Auricle - n. (L. *auricle*, small ear) any ear-like lobed appendages.
Aut- or **auto- -** comb. form. (Gr. from *autos*) a combining form meaning self.
Autogamous - adj., relating to, or reproducing by autogamy.
Autogamy - n. (*aut-* + *-gamy*, Gr. *-gamia*, fr, *gamos*, marriage) self-fertilization, pollination of a flower by its own pollen.
Auxins - growth promoting hormones that cause cell elongation, and are responsible for many developmental responses including phototropism.
Awn - n. (Icel. *ogen*, chaff) a stiff, bristlelike appendage, usually at the end of a structure.
Axil - n. (L. *axilla*, armpit) the angle found between any two organs or structures. The junction of the leaf or petiole and the stem.
Axillary - a. (L. *axilla*, armpit) in an axil, growing in an axil, as buds. Arising from the above junction.
Axillary bud - A bud, capable of developing into a lateral shoot, present in the angle between the stem and a leaf.
Ballast - A transformer which changes the voltage from your house outlet to the voltage needed to power different types of lighting.

Barbel - Whisker-like growths around the mouth, used for finding food and communication; a sensory organ.
Barbellate - a. (L. *barba*, beard) provided, usually laterally, with fine, short points or barbs.
Bark - n. (ME. *barke*; AS. *bare*, bark or rind) the outermost covering of trees and some plants. This is composed of the cuticle or epidermis, the outer bark or cortex, and the inner bark or fiber.
Bases - Compounds that make water Alkaline. If water contains more acids than bases it's acidic. If it has more bases than acids it's alkaline.
Bay - n. (Fr. *baia*; LL. *baia*, bay) a part of a sea or lake indenting the shore line; the word is often applied to very large tracts of water around which the land forms a curve, as Hudson's Bay.
Bayou - n. (Fr. *boyau*, a gut, long narrow passage) a marshy inlet or outlet of a lake, river, etc.; also a backwater.
Berry - n. (AS. *berie*, berry) any fleshy simple fruit with one or more seeds and a skin, as a tomato, cranberry, banana, grape, etc.; a several-sided indehiscent fruit with a fleshy pericarp and without a stony layer surrounding the seeds.
Biennial - a. (L. *biennialis*, from *biennis*; *bis*, twice, and *annus*, year) a plant requiring two years in which to complete its life cycle, the first year growing only vegetatively, the second flowering, fruiting, then dying.
Bifid - a. (L. *bifudus*, forked; from *bis*, twice and *findere*, to cleave, divide) forked; divided by a cleft.
Bilabiate - adj., having two lips, as a bilabiate corolla of a flower.
Bilateral - a. (L. *bilateralis*; *bi*, two, and *latus*, a side) having two sides.
Bilaterally symmetrical - said of corolla or calyx (or flower) when divisible into equal halves in one plane only; zygomorphic.
Bilocular - adj., divided into two cells or compartments.
Bio-balls - A filter media used for the colonization of bacteria.
Biogenic decalcification - When there is a carbon dioxide deficiency in the water, plants can derive CO2 from the hardening constituents of the carbonate hardness. First they split the hydrogen carbonates into CO2 and carbonates. This causes the pH to rise about one step and the largely insoluble carbonates precipitate and form rough deposits on the leaves and substrate. Some plants such as Vallisneria can even destroy the carbonates and obtain CO2 from them. This raises the pH again by another step. Biogenic decalcification thus causes the water to be 10 to 100 times more alkaline than it was previously. In the dark, the process reverses and the pH drops considerably.
Biomass - n. (Gr. *bios*, life; *massein*, to squeeze) weight of all living material in a unit area at an instantaneous time. May be expressed as g/m^2, mt/ha, or other similar expressions.
Biotope - Natural environment of an organism.
Bipinnate -Leaf formed of several leaflets set on either side of the petiole.
Bisexual - a. (L. *bis*, twice; *sexus*, sex) having both female and male reproductive organs present and functional in the same flower; hermaphrodite; amphisporangiate; said of a plant having all bisexual flowers.
Black Water - Water that has a dark cola-like color caused by Humic acids, it has a very low pH and is very soft, common in the Amazon river basin.
Blade - n. (AS. *blaed*, leaf) the leaf of a plant, especially grass; the flat or expanded portion of a leaf; lamina.
Bloom - n. (ME. *blome*, a blossom) a blossom; the flower of a plant; an expanded bud; the opening of flowers in general, leaves, flowers, or fruits.
Blossom - n. (ME. *blossome*, a flower) a flower or bloom, esp. of a fruit bearing plant. A state or time of flowering, literally, and figuratively.
Bog - n. (Ir. *bogach*, a bog, from Gael. *bog*, soft moist) a quagmire covered with grass or other plants; wet, spongy ground; a small marsh; plant community on wet, very acid peat.
Bottomland - n., lowlands along streams and rivers, usually on alluvial floodplains that are periodically flooded.
Brackish - a. mixed with salt; briny.
Bract - n. (L. *bractea*, a thin metal plate) a modified leaf, growing at the base or on the stalk of a flower. It usually differs from other leaves in shape or color. Specialized scale-like leaf found at the base of a flower.
Bracteolate - adj., furnished with bracteoles.
Bracteole - n. (NL. *bracteola*, from L. a thin gold leaf) a small bract; especially one on a floral axis. pl. bracteoles.
Branch - n. (LL. *branca*, paw) a natural division of a plant stem.
Branchlet - n., a small, usually terminal, branch.
Breeding tank - An aquarium set up for the breeding of fish.
Bristle - n. (AS. *bristl*, *byrst*, a bristle) stiff, strong but slender hair or trichome.
Bud - n. (ME. *budde*; AS. *budda*, beetle) a small swelling or projection on a plant, from which a shoot, cluster of leaves, or flowers develops; a rudimentary, undeveloped shoot, leaf, or flower; gemma.
Buffer - A substance added to the water to help maintain the pH value.
Bulb - n. (Fr. *bulbe*; L. *bulbus*; Gr. *bolbos*, a bulbous root) a specialized underground bud that sends down roots and consists of a very short stem covered with leafy scales or layers which store water and nutrients,

the whole enclosing next year's bud. Tightly packed fleshy leaves used as a storage organ. Onions and tulips both have bulbs.
Bullate - Blistered, bubbled or puckered in appearance.
Caducous - a. (L. *caducus*, falling, from *cadere*, to fall) said of a plant part, such as a sepal, petal, or leaf, that falls off quickly or early.
Calcium - A necessary element used by salt water corals and other organisms for their calcium carbonate skeleton or shell.
Callus - n. (L. *callus*, *callum*, hard skin) a hard protuberance or callosity; new tissue covering a wound.
Calyx - n (Gr. *kalyx*, a calyx, cup) the outer covering of a flower external to the corolla, which it encloses, consisting of a whorl of leaves, or sepals, usually of a green color and less delicate in texture than the corolla.
Calyx tube - tube formed by wholly or partially fused sepals. Not the floral tube of an epigynous or perigynous flower.
Cambium - n. (L. *cambiare*, to exchange, more at change) the layer of tissue between the bark and wood in woody plants, from which new wood and bark develops.
Campanulate - a. (Dim. of LL. *campana*, a bell) bell-shaped, usually applied to calyx and corolla.
Cancellate - a. (L. *cancellatus*, pp., of *cancellare*, to make like a lattice) latticed, or resembling a latticed construction, usually said of a surface such as that of an achene or seed.
Capillary - a. (L. *capillaris*, from *capillus*, hair, from *caput*, head) resembling hair in the manner of growth; very slender, threadlike.
Capitate - a. (L. *caput*, head) enlarged or swollen at tip, gathered into a mass at apex, as compound stigma; a knoblike stigma terminating a style.
Capitulum - n. (L. *capitulum*, small head) an inflorescence forming a head of sessile flowers or florets crowned together on a receptacle and usually surrounded by an involucre.
Capsule - n. (L. *capsula*, a little chest) a case, pod, or fruit, containing seeds, spores, or carpels; it usually bursts when ripe.
Carbonate Hardness - The part of the total hardness that is formed by the ions of carbonates(Co3) and hydrogen carbonate(HCo3). It is symbolized by dCH. It is important to know the dCH of your water, as it affects both the pH and Carbon Dioxide amounts in your water. It is also commonly called "buffering capability". A dCH of 4 to 8 is fine for most fish.
Carinate - a. (L. *carinatus*, from *carina*, a keel) shaped like the keel of a ship; having a longitudinal prominence on the back, like a keel; applied to a calyx, corolla or leaf.
Carpel - n. (Gr. *karpos*, fruit) a simple pistil, regarded as a modified leaf; also, any of the two or more carpels that unite to form a compound pistil; the unit of structure of the female portion of a flower.
Carpels - Female sex organs. They contain the Ovules which become seeds when mature.
Carpophore - n. (Gr. *karpophorus*, bearing fruit; *karpos*, fruit, and *pherein*, to bear) generally the organ that supports the carpels; specifically, a very much elongated axis to which the carpels are attached.
Caryopsis - n. (Gr. *karyon*, a nut, and *opsis*, an appearance) a small one-seeded, dry, indehiscent fruit, in which the seed adheres to the thin pericarp, so that the fruit and seed are incorporated into one body, as in wheat and other kinds of grain.
Castanea - n. (L., a chestnut, from Gr. *kastanon*) a genus of trees typified by the common chestnut.
Castaneous - a., relating to or having the color of a chestnut.
Cataphyll - n. (L. from *cata*, and *-phyll*) any rudimentary leaf, as a bud scale, preceding the true foliage leaves.
Cataphyllary leaves - rudimentary or scale-like leaves which act as a covering of buds.
Cation Exchange Capacity (CEC) - Quantifies the ability of media to provide a nutrient reserve for plant uptake. It is the sum of exchangeable cations, or positively charged ions, that media can adsorb per unit weight or volume. It is usually measured in milligram equivalents per 100 g or 100 cm^3 (meq/100 g or meq/100 cm^3, respectively). A high CEC value characterizes media with a high nutrient-holding capacity that can retain nutrients for plant uptake between applications of fertilizer. Media characterized by a high CEC retains nutrients from leaching. In addition, a high CEC provides a buffer from abrupt fluctuations in media salinity and pH. Important cations in the cation exchange complex in order of adsorption strength include calcium (Ca2+) > magnesium (Mg2+) > potassium (K+) > ammonium (NH4+), and sodium (Na+). Micronutrients which also are adsorbed to media particles include iron (Fe2+ and Fe3+), manganese (Mn2+), zinc (Zn2+), and copper (Cu2+). The cations bind loosely to negatively charged sites on media particles until they are released into the liquid phase of the media. Once they are released into the media solution, cations are absorbed by plant roots or exchanged for other cations held on the media particles. **Anion exchange capacity** Some media retains small quantities of anions, (negatively charged ions, in addition to cations). However, anion exchange capacities are usually negligible, allowing anions such as nitrate (NO3-), chloride (Cl-), sulfate (SO4-), and phosphate (H2PO4-) to leach from the media.
Catkin - n. (L. a dim. of *cat*, from its resemblance to a cat's tail) a scaly spike, the flowers of which are unisexual and petalless.

Caudal fin - Single fin at the back of a fish; the tail fin.
Caudex - n. (L. *caudex*, stem of a tree) the base of a perennial plant; the axis or stem of a woody plant, especially of a palm or tree fern.
Caulescent - a. (L. *caulis*, a stem and *-escent*) having a well-developed stem above ground level.
Cauline - a. (L. *caulis*, stalk or stem) stem.
Cellulose - n. (Fr. from L. *cellula*, dim. of *cella*, a small room) the chief substance composing the cell walls or woody part of plants; a carbohydrate of unknown molecular structure but having the composition represented by the empirical formula $(C_6H_{10}O_5)_x$.
Centrum - n. (L. from Gr. *kentron*, center) central portion.
Cespitose - a., growing in tufts or clumps; matted.
Chaff - n. (AS. *ceaf*, chaff) dry scales or bracts, as those on the receptacle subtending the flowers in the heads of certain Compositae.
Channeled - having a deep longitudinal groove.
Chartaceous - a. (L. *chartaceus*, from *charta*, a leaf of paper) having the texture of thin but stiff paper.
Chasmogamy - n. (Gr. *chasma*, an opening, chasm, and *gamos*, marriage) the opening of the perianth of a flower for the purpose of fertilization; contrast with cleistogamous.
Chelators - Synthetic organic acids that bind with various trace elements to keep them available in a form that is usable by the plants.
Chlorophyll - The pigment that makes plants green. One of the pigments necessary for photosynthesis.
Chlorophyll Absorption - Process of Photosynthesis, occurs between 420-550 nm. and at 670 nm. Values for different type bulbs.
Chlorosis - Loss of chlorophyll, often a sign of insufficient amounts of iron. n. (Gr. *chloros*, pallid) An abnormal condition characterized by absence of green pigments in plants.
Choripetalous - a. (Gr. *choris*, apart, and *petalon*, leaf) polypetalous; having unconnected or separate petals.
Ciliata - a. (L. *cilium*, eyelid) with marginal hairs that form a fringe.
Circumscissile - a. (L. *circum*, around; *scindere*, to cut) opening splitting by a transverse fissure around the circumference, leaving an upper and lower half; said of certain seed pods or capsules.
Clavata - a. (L. *clava*, a club) club-shaped; having the form of a club; growing gradually thicker toward the top, as certain parts of a plant.
Claw - n. (AS. *clawu*, a claw, hoof) the narrowed, stalk-like base of some sepals or petals.
Cleft - a. (AS. *cleofan*, to cut) divided halfway down to the midrib or further, or generally, any deep lobe or cut.
Cleistogamy - n. (Gr. *kleistos*, closed; gamos, marriage) the condition of having flowers which never open and self-pollination occurs; the flowers are often small and inconspicuous.
Clone - n. (Gr. *klon*, a twig) a group of plants, all of whose members are directly descended from a single individual.
Coagulant - A chemical compound used in water clarifiers. It causes fine particles to stick together to be more easily removed by the filter.
Coherent - a. (L. *cohaerere*, to stick together) having parts united.
Collar - n. (L. *collare*, a band or chain for the neck) region of junction between blade and leaf sheath of grasses.
Collenchyma - n. (L. from Gr. *killa*, glue, and *enchyma*, an infusion) living, supportive tissue with chloroplasts generally just beneath the surface consisting or more or less elongated cells usually thickened unevenly in a manner somewhat variable in different groups of plants.
Colonial - a. (Fr. *colonial*, from L. *colonia*, a colony) usually used to describe cloning by vegetative reproduction, the seemingly separate plants having arisen from rhizomes, stolons, or roots of a single or of neighboring "parent" plants.
Colony - n., a stand, group, or population of neighboring plants of one species, the origin having been colonial, from seeds, or both.
Colpate - adj. (Gr. *kolpos* + *E-ate*, of pollen grains) having longitudinal germinal furrows in the exine.
Coma - n. (L. *coma*; Gr. *kome*, hair) a tuft of soft hairs, as at the apices or bases of seeds; a bunch of branches; a terminal cluster of bracts on a flowering stem, as in pineapples.
Commissure - n. (L. *commissura*, a joining together) a place of joining or meeting, as where one carpel joins another in the Umbelliferae.
Communities - Different species of fish kept in the same aquarium.
Comose - a. (L. *comosus*, hairy, from *coma*, hair) having a tuft of hair.
Competition - n. (L. *competitio*, an agreement, rivalry) involves the removal or reduction of some factor from the environment by a plant or group of plants that is sharing the same habitat. Competition can be by an individual or groups of plants of the same or different species. Factors that may be reduced include water, minerals, food, and light.
Compound leaf - A leaf that is divided into several distinct leaflets.

Concretion - n. (L. *concretion*, *concretio*, to grow together) the act or process of making or becoming solid.
Connate - adj. (LL. *connatus*, past part) congenitally united.
Connivent - a. (L. *connivere*, to close the eyes) approximate but not organically united; converging; arching over so as to meet.
Contraction - The shedding of the leaves at the onset of the dormant period.
Convexity - Having the property of curving outward, like the outside of a ball.
Convolute - a. (L. *cum*, together; *volvere*, to wind) said of parts rolled or twisted together when in an undeveloped stage, as in some corollas in the bud stage.
Cordate - a. (L. *cor*, *cordis*, a heart) with a sinus and rounded lobes at the base, the overall outline usually ovate; often restricted to the base rather than to the outline of the entire organ; heart-shaped.
Coriaceous - a. (L. *coriaceus*, from *corium*, leather) leathery; tough.
Corm - n. (L. *cormus*; Gr. *kormus*, the trunk of a tree with the boughs lopped off) an enlarged solid subterranean stem, often rounded in shape but of no distinct characteristic shape or size in some species, filled with nutrients, composed of two or more internodes and covered externally by a few thin membranous scales or cataphyllary leaves.
Cormophyta - n. (Gr. *kormus*, the trunk of a tree with the boughs lopped off; *phyton*, plant) in older classifications, a division comprising all plants that have a stem and root.
Cormophyte - n., a plant of the division Cormophyta.
Corolla - n. (L. *corolla*, a little crown) the inner, usually colored or otherwise differentiated, whorl or whorls of the perianth; the petals of a flower as a whole.
Corymb - n. (Gr. *korys*, a helmet) a racemose type of inflorescence in which the lower pedicels are successively elongated, forming a more or less flat-topped inflorescence, the outer flowers opening before the inner.
Cosmopolitan - Found worldwide.
Cotyledon - n. (Gr. *kotyle*, a hollow or cavity) the first leaf or leaves of a seed plant, found in the embryo of the seed which may form the first photosynthetic leaves or may remain below ground.
Creek - n. (ME. *creke*, *crike*, from ON. *-kriki*, bend, concavity; akin to ON. *krikr*, bend, bay) a natural stream of water normally smaller than, and often tributary to, a river.
Crenate - a. (L. *crena*, a notch) having a notched, indented, or scalloped edge, as certain leaves.
Crenate - Edged with rounded teeth.
CRI: color rendering index **-** A number used for rating light bulbs on a scale up to 100, where 100 is equal to sunlight.
Crispate - With wave margins.
Crown - n. (L. *corona*, a crown, wreath) that part of a stem at or just below the surface of the ground; an inner appendage of a petal or the throat of a corolla; an appendage or extrusion standing between the corolla and stamens, or on the corolla; an outgrowth of the staminal part or circle as in milkweeds.
Crushed coral - A Calcareous substrate material with pH buffering abilities, for marine aquaria.
Culm - n. (L. *culmus*, a stalk, stem) the stalk or stem for such plants as grasses and sedges, usually jointed and hollow.
Cultivar - A man-made (cultivated) variety.
Cuneate - a (L. *cuneatus*, wedge-shaped, from *cuneus*, a wedge) narrowly triangular with the acute angle toward the base; wedge-shaped; tapering toward the point of attachment.
Cusp - n. (L. *cuspis*, a point) rigid, sharp point, especially on a leaf.
Cuspidate - a. (L. *cuspidare*, to make pointed) tipped with a short, rigid point.
Cuticle - n. (L. *cutis*, skin) a continuous layer of fatty substances covering over the outer surfaces of the epidermis of plants; it contains cutin and protects against water and gases. The thin skin of the plant. This is thicker and waxy to maintain moisture in emersed growth.
Cutin - n., a waxy substance which, together with cellulose, forms the outer layer of the skin of many plants.
Cutting - A fragment of plant material that is capable of growing to become another complete, individual plant.
Cuttings - Detached parts of stem plants: they take root after planting and become new plants.
Cyathium - n. (Gr. *kyathos*, cup) a type of inflorescence characteristic of some members of Euphorbiaceae; consisting of a cuplike involucre bearing unisexual flowers; staminate on its inner face, pistillate from the base.
Cyme - n. (Gr. *kyein*, to swell) a cluster of flowers in which each main and secondary stem bears a single flower, the bud on the main stem blooming first; determinate inflorescence in which each growing point ends in a flower.
Cymose - a., bearing a cyme or cymes.
Cystolith - n. (Gr. *kystis*, bladder; *lithos*, stone) a mass of calcium carbonate concretion, occasionally silica, formed on ingrowths of modified epidermal cell walls in some plants, esp. of the Acanthaceae family.
Day neutral plants - plants that flower regardless of day length.
Deciduous - a. (L. *deciduus*, that which falls down) falling after completion of the normal function.

Decimeter - (dm), 3.973 inches, 10 cm, or 0.1 m.
Decumbent - a. (L. *decumbere*, to lie down) trailing on the ground and rising at the tip, as some stems.
Decurrent - a. (L. *decurrere*, to run down) extending downward, applied usually to leaves in which the blade is apparently prolonged downward as two wings along the petiole or along the stem.
Decussate - Opposite pairs of shoots set at right angles to the pairs above and below.
Dehiscence - n. (L. *dehiscere*, to gape) opening and shedding contents; said of stamens and fruits.
Dehisces - vt., to burst or split open, as the seed capsules of plants.
Deltoid - a. (Gr. *delta*, and *eidos*, form) shaped like the Greek letter delta; triangular in outline.
Denitrification - Breakdown of nitrates by anaerobic bacteria into other forms.
Dentate - a. (L. *dens*, a tooth) toothed, with large saw-like teeth on the margin pointing outward, not forward.
Denticle - n. (L. *denticulus*, little tooth) a small tooth or toothlike projecting point.
Denticulate - a., having small teeth; finely dentate. Serrated, edged with small teeth.
Detritus - Organic waste matter that collects on the bottom of fish tanks.
Diadelphous - a. (from *di-*, twice, and Gr. *adelphos*, brother; *-ous*) in two sets as applied to stamens when in two, usually unequal, sets.
Dichotomous - a. (Gr. *dichotous*, a cutting in two) having or consisting of a pair or pairs; paired. Dividing into two equal branches.
Digitate - a. (L. *digitus*, finger) having fingerlike divisions, as some leaves.
Dimorphic - a. (Gr. *dimorphos*, having two forms) having two forms.
Dioecious - a. (Gr. *di*, two; *oikos*, house) said of a kind of plant having unisexual flowers, the male and female flowers on different individual plants.
Dioecious - Having male or female flowers on separate plants.
Diploid - a. (Gr. *diploos*, double; *eidos*, form) having twice the number of chromosomes normally occurring in a germ cell.
Disc flowers - the radically symmetrical flowers of the head in Compositae, as distinguished from the ligulate ray flowers.
Discoid - a. (Gr. *diskos*, a disk) having the form of a disk; discoid flower; a compound flower not radiated, but with tubular florets.
Distal - a. (L. *distare*, to stand apart) farthest away from the point of attachment or origin.
Distichous - a. (Gr. *distichos*, having two rows) two-ranked; in the case of plants with alternate leaves, the arrangement is such that 1st is directly below the 3rd.
Distichous - Leaves arranged in two rows on either side of the stem.
Divaricate - vt. (L. *divaricare*, to spread apart) to branch or spread widely apart.
Divergent - a. (L. *divergere*, to bend away) separated from one another, having tips further apart than the bases
Diverticulate - a. (L. *divertere*, to turn aside) having short offshoots approximately at right angles to axis.
Divided - a. (L. *dividere*, to divide) referring to the blade of an appendage when it is cut into distinct divisions to, or almost to, the midvein.
Division - A method of propagation in which the rhizome or vegetative cone is cut into pieces, each of which is capable of becoming a complete new plant. Division of the vegetative point of Rosette plants into two or more parts for propagation.
DKH - Abbreviation for Degrees of Carbonate Hardness.
Dolomite - A limestone gravel with a small pH buffering ability.
Dormant period - Interruption of growth in an effort to adjust to seasonal periods of stress.
Dorsal - a. (L. *dorsum*, the back) pertaining to the back; the surface turned away from the axis.
Dorsal fin - Single fin mounted on top of the fish. Some species have two, one behind the other.
Down - n. (ME. *down*, *downe*, down; probably of Scandinavian origin) fine, soft feathers; soft, fine hair.
Downy - a., covered with short, fine hairs.
Drupe - n. (Gr. *dryppa*, an overripe olive) a fleshy or pulpy fruit with the inner portion of the pericarp hard or stony and enclosing the seed; usually 1-locular and 1-seeded, sometimes more than 1-locular and more than 1-seeded.
Echinate - a. (L. *echinus*, a hedgehog) set with prickles; prickly, like a hedgehog; having sharp points.
Ecology - n. (Gr. *oikos*, house; and *-logy* Gr. *-logia*, from *legein*, to speak) branch of science concerned with the interrelationships of organisms and their environments esp. as manifested by natural cycles and rhythms, community development and structure, interaction between different kinds of organisms, geographic distributions and population alteration.
Edaphic - a., relating to, or determined by, conditions of the soil.
Elliptic - a. (Gr. *elleipsis*, a falling short, defect, ellipse) an outline that is oval, narrowed to rounded at the ends and widest at about the middle (as the outline of a football); ellipsoid, a solid with an elliptical outline.
Emarginate - vt. (L. *emarginare*, to deprive of the edge) said of leaves, sepals, or petals, and other structures that are notched at the apex.
Emerge - vt. (L. *emergere*, to rise up, rise out) to rise out of a fluid or other covering.

Emergent - n., (ME. Fr. L. *emergent-*, emergens, pres. part. of *emergere*, to emerge - more at emerge) any of various plants (as a cattail) rooted in shallow water and having most of the vegetative growth above the water.
Emersed - Grown so that the roots and bottom portion of the plant are underwater, and the rest of the plant grows above the water. adj., Standing out of or rising above a surface as an aquatic plant with flower stalk emersed.
Emersed plants - plants growing with their roots and a portion of the shoot below the water and the remainder of the shoot above the surface of the water.
Enation - n. (L. *enasci*, to spring up) an abnormal growth of an organ or of an excresence upon any part of a plant.
Endcap - A water resistant socket for fluorescent lamps.
Endemic - a. (Gr. *endemos*, native, belonging to a people) a plant that is native to a particular country or region; not introduced or naturalized. A species found only in one specific location.
Endocarp - n. (Gr. *endo*, within; *karpos*, fruit) the inter layer of the wall of a matured ovary; when its texture differs from the outer wall, it may be hard and stony, membranous, or fleshy.
Ensiform - adj. (F. *ensiforme*, Fr. L. *ensis* sword + F. *forme*, form) having sharp edges and tapering to a slender point; having a shape suggesting a sword.
Entire - a. (L. *integer*, whole, untouched, undiminished) having a margin devoid of any indentations, teeth, or lobes.
Entomophilous - a. (Gr. *entomon*, insect; *philein*, to love) pollination by insects.
Ephemeral - n. (Gr. *ephemeros*, lasting for a day) referring to an organ living a very short time, usually a day or less; lasting a very short time.
Epigynous - a. (Gr. *epi*, upon; *gyne*, woman) growing upon the top of the ovary or seeming to do so, as petals, sepals, and stamens.
Epigyny - n., the condition of being epigynous.
Epipetalous - a. (Gr. *epi*, upon; *petalon*, leaf) having stamens inserted on petals.
Epiphytic - A plant that grows on another plant but is not parasitic.
Equitant - a. (L. *equitare*, to ride) overlapping; said of leaves whose bases overlap the leaves within or above them, as in the Iris.
Erose - a. (L. *erodere*, to wear away) having small irregular notches in the margin, as if gnawed.
Essential flower parts - the stamen and pistil organs of the flower that are required for pollination.
Estuary - n. (L. *aestuarium*, part of the seacoast over which the tide ebbs and flows, from aestus, the tide) an inlet or arm of the sea; especially the wide mouth of a river, where the tide meets the current. pl. estuaries.
Etiolation - The formation of weak, spindly foliage deficient in Chlorophyll, usually occurs in light of too low intensity.
Eutrophic - a. (Gr. *ew*, well; *trophe*, nourishment) the gradual increase in nutrients in a body of water. Natural eutrophication is a gradual process, but human activities may greatly accelerate the process. Rich in dissolved nutrients, often caused by pollution.
Eutrophication - a., the process of becoming eutrophic.
Even-pinnate - said of compound leaves having an even number of leaflets, this is usually easily determined because there is a pair terminally.
Excrescence - n. (L. *excrescere*, to grow out; *ex*, out; *crescere*, to grow) a normal outgrowth; a disfiguring addition.
Excurrent - a. (L. *excurrere*, to run out, project) projecting beyond the tip, as the midrib of a leaf or bract.
Exfoliate - vt. (L. *ex*, out; *folium*, leaf) peeling off in thin layers, shreds, or plates, as the bark of some trees.
Exine - n. (L. *ex*, out of, out) the outer of two layers forming the wall of certain spores (as pollen grains) - called also exosporium.
Exocarp - n. (Gr. *exo*, without; *karpos*, fruit) the outer layer of the wall of a matured ovary.
Exsert - vt. (L. *exserere*, to stretch out) to put forth; to thrust out; to protrude.
Exserted - a., sticking out; extending beyond (some enclosing part).
Exstipulate - a. (L. *ex*, private; *stipula*, a stalk, stem) having no stem.
Falcate - a. (L. *falx*, a sickle) curved like a sickle.
Family - A term used in the classification of organisms. A family is made up of related Genera.
Farinaceous - a. (L. *farina*, meal) containing flour; starchy; mealy.
Farinose - a., full of meal; mealy; covered with a white, powdery substance.
Fascicle - n. (L. *fasciculus*, small bundle) a small bundle or tuft, as of fibers, leaves, etc.
Fastigiate - a. (L. *fastigare*, to slope up) branches erect and close to stem.
Fen - n. (ME. *fen*, *fenne*; AS. *fen*, *fenn*, a marsh, bog, fen) low land covered wholly or partially with water but producing sedge, coarse grasses, or other aquatic plants; boggy land; a moor or marsh; plant community on alkaline, neutral, or slightly acid peat.

Fenestrated - a. (L. *fenstra*, window) a type of leaf anatomy with small perforation or transparent spots. Confined to a few tropical monocotyledons which grow on the island of Madagascar.
Filament - n. (L. *filum*, thread) the stalk bearing the anther.
Filiform - a. (L. *filum*, thread; *forma*, shape) thread-like, long and very slender. Thread like.
Filtration - Method of cleaning aquarium water. There are 3 basic types: "Mechanical" removes particulate material. “Chemical" is removal of dissolved substances by passing through a type of media, like carbon. "Biological" is the process of changing from a harmful substance to a less harmful one, by bacteria.
Fimbriate - n. (L. *fimbriatus*, fringed) cut into regular segments and appearing fringed at the margins.
Fistula - n. (L. *fistula*, pipe) pathological or artificial pipe-like opening; water-conducting vessel - alt. trachea.
Fistulose - a. same as fistulous.
Fistulous - a, having the form or nature of a fistula.
Flabellate - a. (L. *flabellare*, to fan) fan-shaped.
Flaccid - a. (L. *flaccidus*, flabby) weak, limp, soft, or flabby; leaves that do not have enough water and are about to wilt or are wilting.
Floccose - a. (L. *floccus*, a lock of wool) said of pubescence which gives the impression of irregular tufts of cotton or wool.
Florescence - n. (L. *florescence*, to begin to flower) bursting into bloom, alt. anthesis.
Floret - n. (L. *flos*, flower) one of the small individual flowers of a crowded inflorescence such as capitulum; flower with lemma and palea, of grasses; alt. floscule.
Floricane - n., the stem at flowering and fruiting stage (of a bramble, Rubus).
Floscule - n. (L. *flosculus*, little flower) a small flower; a floret.
Flower - n. (ME, *flowre*, *flour*, *flur*; OFr., *flor*, *flur*, *flour*, from L. *flos*, *floris*, a flower) the part of a plant containing or consisting of the organs of reproduction, either together in a monoclinous flower or separate in male and female flowers.
Foliaceous - a. (L. *folium*, leaf) having the form or texture of a foliage leaf; thin and leaf-like; bearing leaves.
Follicle - n. (L. *folliculus*, small sac) a dry dehiscent fruit formed of one carpel, and dehiscing along one side.
Fresh weight - same as wet weight. Generally not a useful measurement for aquatic plants.
Frond - n. (L. *frons*, a leafy branch) a leaf, especially of fern or palm; a leaf-like expansion.
Frond - The "leaf" of a fern.
Fruit - n. (Fr. *fruit*, from L. *fructus*, fruit) the developed ovary of the flower containing ripe seeds, whether fleshy or dry, often used to include other associated parts such as a fleshy receptacle, then called a false fruit.
Frutescent - a. (L. *frutex*, a shrub) shrubby or becoming shrubby.
Funicle - n. (NL. *funiculus*) funiculus.
Funiculus - n. (NL. from L. *funis*, a small rope) the stalk of an ovule. pl. funiculi.
Fusiform - a. (L. *fusus*, a spindle; *forma*, form) shaped like a spindle; thick, tapering at both ends.
Gametophyte - n. (Gr. *gamete*, a wife; *phyton*, plant) the gamete-forming haploid phase in the alternation of plant generations.
Gamopetalous - a. (Gr. *gamos*, marriage; *phyllon*, a leaf) having the petals united so as to form a tubelike corolla. Same as sympetalous.
Gamosepalous - a. (Gr. *gamos*, marriage; *sepalous*) having the sepals united.
Gemma - n. (L. *gemma*, a swelling, bud, gem) a bud or outgrowth of a plant which develops into a new organism. A leaf bud rather than a flower bud.
Gemmates - a. (L. *gemmare*, to put forth buds) buds or outgrowths of a plant which develop into a new individual.
Gemmiparous - a. (L. *gemma*, a bud; *parere*, to bear) to produce gemmates.
General or Total hardness - the sum of carbonate hardness and non-carbonate hardness. Usually expressed in degrees of dH.
Geniculate - a. (L. *geniculatus*, having knee joints, joints) bent like a knee; bent abruptly at the nodes.
Genotype - n. (Gr. *genos*, race; type) the genetic constitution of an individual.
Genus - n. (L. *genus*, race) a taxonomic group consisting of closely related species, genera being grouped into families; plural - genera; a. - generic.
Geophyte - n. (Gr. *ge*, earth; *phyton*, plant) plants with an underground dormant part such as a tuber, bulb, rhizome, etc. to help the plant survive adverse conditions.
Gibberellins - n. (*Gibberella*, a fungal genus) growth hormones that accelerate shoot growth. First discovered in the fungus *Gibberella fujikuroi*, and later in other plants.
Gibbous - a. (L. *gibbus*, hump) a distended, rounded swelling on one side, as on a calyx or corolla tube or segment.
Glabrate - a. (L. *glaber*, smooth) becoming glabrous with age.
Glabrous - a., with a smooth, even surface; without hairs.

Glade - n. (prob. Scand. *golead*, a lighting, illumination, fr. *goleu*, light, clear, AS. *glaed*, bright) open space surrounded by woods or a forest; a marshy and usually low-lying area; a periodically inundated grassy marsh often running between adjacent slopes; a marshy area bounding or forming the headwaters of a stream.
Gland - n. (L. *glands*, acorn) a secreting part or appendage.
Glandular - a. (L. *glandula*, small acorn) having or bearing secreting organs, glands, or trichomes.
Glandular-pubescent - hairs or trichomes capitate and secretory.
Glaucous - a. (L. *glaucus*, sea-green) bluish green; covered with a pale green bloom.
Globose - a. (L. *globosus*, rounded as a ball) rounded; almost spherical; globular.
Glomerate - vt. (L. *glomus*, a ball of yarn) to gather or wind into a ball; growing, collected or arranged in a rounded mass, as glands, flowers, etc.; clustered.
Glomerule - n., a condensed cyme of almost sessile flowers; a compact cluster as of spores.
Glume - n. (L. *gluma*, husk) a chaffy or membranous bract, a bract at the base of a grass inflorescence or spikelet.
Glutinous - a. (L. *gluten*, glue) having a sticky, moist surface; a gluey or sticky exudation.
Guttation - n. (L. *gutta*, drop) formation of drops of water on plants from moisture in air; the process of water being exuded from hydathodes at the enlarged terminations of veins around the margins of the leaves.
Gymnospermae - n. (Gr. *gymnos*, uncovered, naked; *sperma*, seed) an important division of the plant kingdom, being woody plants with alternation of generations, having the gametophyte retained on the sporophyte and seeds produced on the surface of the sporophylls and not enclosed in an ovary.
Gynaecium - n. (Gr. *gynaikeie*, woman's part of a house) the female organs of the flower, consisting of one or more carpels forming one or several ovaries with their stigmas and styles.
Gynecandrous - a., having staminate and pistillate flowers in the same spike or spikelet, the latter above the former.
Gynoecium - n. (Gr. *gyne*, woman; *oikos*, house) the pistil or pistils of a flower, taken collectively; gynaecium.
Gynophore - n. (Gr. *gyne*, woman; *pherein*, to carry) a stalk supporting the ovary.
Gynostegium - n. (Gr. *gyne*, woman; *stege*, roof) a protective covering for a gynaecium, especially as formed by the union of stamens and style.
Habit - n. (L. *habitus*, condition, appearance, dress) the external appearance or way of growth of a plant, e.g. climbing, erect, bushy, etc.; the tendency of a plant to grow in a certain way.
Habitat - n. (L. *habitare*, to inhabit) the locality or external environment in which a plant lives.
Halophyte - n. (Gr. *hals*, salt; *phyton*, plant) any species capable of tolerating 0.5% or more NaCl.
Haplophyte - n. (Gr. *haploos*, simple; *eidos*, form) having the number of chromosomes characteristic of the gametes for the organism.
Hapteron - n. (Gr. *haptein*, to fasten) holdfast, specialized root-like projections that function to anchor a plant.
Hard water - Water with a high concentration of dissolved salts.
Hastate - a. (L. *hasta*, spear) spear shaped, more or less triangular with the two basal lobes divergent. With two out-turned lobes at the base.
Hemicryptophyte - n. (Gr. *hemi*, half; *kryptos*, hidden; *phyton*, plant) a perennial plant having its overwintering buds located at the soil surface.
Herb - n. (L. *herba*, green crop) any seed plant whose stem withers away to the ground after each season's growth; a seed plant with a green, non-woody stem.
Herbage - n. (Fr. *herbe*, an herb) herbs collectively; the green foliage and juicy stems of herbs.
Herbivore - Plant eater.
Heterophyllous - Having leaves of different shapes on the same plant. a. (Gr. *heteros*, other; *phyllon*, leaf) the presence on a single individual of two or more distinct leaf shapes. These leaves may differ markedly in shape, yet have similar gross anatomical organization.
Heterostylic - Having flowers which differ in the relative length of their styles and stamens, such that any one flower is very rarely, if ever, self pollinated.
Heterozygote - n. (Gr. *heteros*, other; *zygon*, yoke) an organism or cell having two different alleles at corresponding loci on homologous chromosomes.
Hibernaculum - n. (L. *hibernare*, winter residence) a plant organ such as a bud, rhizome, turion, etc. which allows a plant to live through adverse conditions
Hilum - n. (L. *hilum*, a little thing, a trifle) the scar on a seed marking the place where it was attached to the seed stalk.
Hirsute - a. (L. *hirsutus*, bristly) set with bristles; hairy; shaggy.
Hispid - a. (L. *hispidus*, rough) having stiff hairs, spines, or bristles.
Hyaline - a. (Gr. *hyalos*, glass) of thin, membranous, transparent or translucent texture.
Hybrid - n. (L. *hibrida*, cross) any cross-bred plant; heterozygote. The offspring of two parents of different species or varieties.

Hydathodes - n. (Gr. *hydatos*, of water; *hodos*, way) an epidermal structure specialized for secretion, or for exudation, of water.
Hydric - a. (Gr. *hydor*, water) characterized by an abundant supply of water.
Hydrometer - A device used to measure salinity of water.
Hydrophilous pollination - The transference of pollen from the Anthers of the Stamens to the Stigmas on the surface of the water or under water.
Hydrophily - n. (Gr. *hydor*, water; *philein*, to love) water pollination.
Hydrophyte - n. (Gr. *hydor*, water; *phyton*, plant) an aquatic plant living on or in water.
Hydropote - n. (Gr. *hydropotes*, water drinker) a cell or cell group found on the lower epidermis of some species such as *Nymphaea*. These cells are thought to function in the uptake of ions from the water.
Hypanthium - n. (Gr. *hypo*, under; *anthodes*, like flowers) an expansion of the receptacle of a flower that forms a saucer-shaped, cup-shaped, or tubular structure (often simulating a calyx tube) bearing the perianth and stamens at or near its rim; it may be free from or united to the ovary.
Hypertrophy - n. (Gr. *hyper*, above; *trophe*, nourishment) excessive growth due to increase in cell size.
Hypocotyl - The part of the Stem of a seedling below the cotyledons.
Hypogynous - a. (Gr. *hypo*, under; *gyne*, female) inserted below the gynoecium, and not adherent; immediately below oogonium; the ovary thus said to be superior. n. hypogyny.
I.D.- An abbreviation for inside diameter, used when measuring tubing dimensions.
IAA - Indole-acetic acid, a natural growth hormone found in plants.
Ich - A very common parasitic disease characterized by white salt-like specks all over the fish.
Idioblasts - n. (Gr. *idios*, one's own; *blastos*, a bud, offshoot) plant cells containing oil, gum, calcium, or other products, and appearing to help provide mechanical support.
Imbricate - a. (L. *imbricare*, to tile) having parts overlapping each other like roof tiles.
Immersed - a. (L. *in*, into; *mergere*, to dip, plunge) growing under water.
Imperfect flower - a flower containing stamen and pistil organs required for pollination but lacking sepals or petals or both of these organs.
Incised - a. (L. *in*, into; *caedere*, to cut) with sharp angles between the lobes; having deeply cleft margins.
Included - a. (L. *in*, in; *claudere*, to shut, close) not projecting beyond an enclosing part.
Incrassate - vt. (L. *in*, in; *crassus*, thick) becoming thick or thicker, especially toward a tip or margin.
Indehiscent - a (L. *in*, not; *dehiscens*, gaping) fruits which do not open to release seeds, but whole fruit is shed from the plant; not opening to release spores.
Indigenous - a. (L. *in*, within; *gignere*, to bear, produce) native; originating or occurring naturally in the place specified.
Inflorence - Flower cluster.
Inflorescence - n. (L. *inflorescere*, to begin to blossom) a flower or putting forth blossoms; the mode of development and arrangement of flowers on an axis; a flowering branch.
Infructescence - n. (L. *in*, into; *fructus*, fruit) the inflorescence in a fruiting stage; collective fruits.
Inter- - (ME. *enter-*, *inter-*; OFr. *entre-*, *inter-*; L. *inter-* from *inter*, prep. between, among, during) a prefix meaning between, among - as intercellular.
Intercellular - adj. lying between cells, as intercellular space in plant tissue.
Interference - n. (L. *inter*, between; *ferire*, to strike) the overall influence of one plant or groups of plants on another, and encompasses allelopathy or competition, or both of these processes.
Internode - n. (L. *inter*, between; *nodus*, knot) the portion of a stem between nodes. The area between two nodes on a plant stem.
Interspecific competition - competition between species for nutrients, space, light, etc.
Intra- - (L., from *intra*, within, inside) a combining form meaning within, inside of, as intracellular.
Intracellular - adj., being or occurring within a body cell or within the body cells.
Intraspecific competition - a type of competition whereby an individual plant competes with one or more members of the same species for nutrients, space, light, etc.
Invertebrate - An animal with no backbone.
Involucel - n. (L. *involucrum*, covering) a secondary involucre, as the bracts subtending the secondary umbels in the Umbelliferae.
Involucre - n., a group of closely placed bracts that subtend or enclose an inflorescence.
Involute - a. (L. *involutus*, rolled up) leaves having the edges rolled inwards at each side, toward the adaxial side.
Involution - n. (L. *involutus*, rolled up) a rolling inwards of leaves.
Iron - The most important trace element for plants. Iron deficiency causes Chlorosis; a disease that makes the plant leaves Yellow.
Kelvin - A temperature reading used to rate the color of light bulbs. 5500 degrees K is equal to sunlight.
Labiate - a. (L. *labium*, lip) lipped, as in a calyx or corolla.
Lacerate - a. (L. *lacer*, mangled, lacerated) said of a margin torn irregularly.
Laciniate - a. (L. *lacinia*, a hem) cut into narrow, jagged lobes or segments.

Lacunate - a. (L. *lacuna*, cavity) with air spaces or chambers in the midst of tissue.
Lagoon - n. (It. And Sp. *laguna*, fr. L. *lacuna*, a ditch, pool, fr. lacus, lake) a shallow lake or pond, especially one connected with a larger body of water; an area of shallow salt water separated from the sea by sand dunes; the area of water surrounded by an atoll, or circular coral reef.
Lake - n. (ME. *lake*, *lak*; AS. *lacu*, a lake, pool; L. *lacus*, a hollow, a basin, tub, pool, lake) an inland body of water, usually fresh water, formed by glaciers, river drainage, etc., larger than a pool or pond.
Lamellate - a., made up of thin plates or lamina.
Lamina - n. (L. *lamina*, a thin piece of metal or wood) the expanded blade part of a foliar leaf, petal, etc. The part of a leaf which is flattened, to a greater or lesser degree; as the Leaf Blade.
Laminae - Broad part of the leaf usually attached to the stalk by the petiole; also called the blade.
Lanate - a. (L. *lana*, wool) wooly, with long intertwined, curled hairs.
Lanceolate - a. (L. *lancea*, a lance) shaped like a lance; broadest toward the base and narrowed to the apex, several times longer than wide.
Lanceolate - Spear shaped.
Lateral line - A line of sensory scales along the sides of fish that enables them to detect vibrations and electrical impulses from other fish.
Laterite - An iron-bearing red soil found in tropical areas. Formed by centuries of heat and rain. Substance used in fresh water plant tanks to supply nutrients, either a powder placed under the gravel or chunks mixed in the gravel bed.
Leaf - n. (ME. *leef* fr. OE. *leaf*, akin to OHG. *loub*, leaf, foliage) a lateral outgrowth from a stem that constitutes part of the foliage of a plant and functions primarily in food manufacture by photosynthesis.
Leaflet - One part of a compound leaf.
Legume - n. (L. *legere*, to gather) a 1-locular fruit, usually dehiscent along two sutures, bearing seeds along the ventral suture; a leguminous plant.
Lemma - n. (Gr. *lemma*, husk) the lower (abaxial), and larger, of two membranous bracts enclosing the flower in grass.
Lenticel - n. (L. *lens*, *lentis*, lentil) corky spots on young bark, arising in relation to epidermal stomates.
Lenticular - a. (L. *lenticula*, a lentil) shaped like a double-convex lens.
Lignify - vt., to convert into wood or woody tissue; to become wood or woody by chemical and physical changes in the cell walls that convert some or all of the constituents into lignin or lignocellulose.
Lignin - n. (L. *lignum*, wood) organic substances which act as binders for the cellulose fibers in wood and certain plants, and adds strength and stiffness to the cell walls. Chemical structure of lignin is composed of a polymer of high carbon content but distinct from the carbonates. Consists of C6,C3 units.
Ligulate - a. (L. *ligula*, little tongue) having or pertaining to ligules.
Ligule - n., hyaline extension of the leaf sheath on the adaxial side of the leaf.
Limb - n. (AS. *lim*, limb) the spreading part of a synsepalous calyx or sympetalous corolla, usually referring only to the calyx or corolla lobes, sometimes to their lips.
Limnology - n., the scientific study of physical, chemical, meteorological, and biological conditions in fresh waters.
Linear - a. (L. *linea*, line) long and slender with parallel or nearly parallel sides. Long, narrow, grass-like or strap-like leaf.
Lip - n. (AS. *lippa*, *lippe*, lip) the upper or lower part of a bilabiate calyx or corolla.
Lobulate - a. (Gr. *lobos*, lobe) divided into small lobes.
Locular - a. (L. *loculus*, a cell, box) having the nature of, or consisting of cells.
Locule - n. (L. *loculus*, a cell, box) a compartment of an anther or an ovary.
Loculicidal - a. (L. *loculus*, a cell, box; *caedere*, to cut) dehiscent dorsally down middle of carpels.
Lodicule - n. (L. *lodicula*, coverlet) a scale at base of an ovary in grasses, supposed to represent part of a perianth.
Loment - n. (L. *lomentum*, bean meal) a fruit of some legumes, contracted between the seeds, the 1-seeded segments separating at fruit maturity.
Long-day plant - a plant that requires more than 12 hours of daylight before flowering will occur.
Lumens - A measurement of light intensity. (1 lumen=10.76 lux).
Lunate - a. (L. *luna*, moon; *-ate*) crescent-shaped.
Lux - The standard for measuring light.
Macronutrients - Nutrients used by plants in relatively large amounts. They are nitrogen (N), phosphorus (P), sulfur (S), calcium (Ca), magnesium (Mg) and potassium (K).
Macrophyte - n. (Gr. *makros*, large; *phyton*, plant) a member of the macroscopic plant life especially of a body of water; large aquatic plant; the term 'aquatic macrophyte' has no taxonomic significance.
Macroscopic - a. (Gr. *makros*, large; *skopein*, to view) items large enough to be observed by the naked eye.
Marcescent - a. (L. *marcescere*, to wither) withering but remaining persistent.

Marsh - n. (ME. *mersh*, meadowland) a tract of wet land principally inhabitated by emergent herbaceous vegetation.
Membranous - a. (L. *membrana*, mem- brane) having a thin, soft, pliable texture.
Mericarp - one of the two carpels that resembles achenes and forms the schizocarp of an umbelliferous plant.
Mesic - a. (Gr. *mesos*, middle) conditioned by temperate moist climate; neither xerix nor hydric; pertaining to conditions of medium moisture supply.
Micronutrients - Nutrients used by plants in small amounts. They are iron (Fe), manganese (Mn), copper (Cu), zinc (Zn), molybdenum (Mo), cobalt (Co), and boron (B).
Microphyllidious - small, leaf-shaped.
Mire - n. - synonymous with any peat-accumulating wetland.
Moniliform - a. (L. *monile*, necklace; *forma*, shape) constricted laterally and appearing beadlike.
Monoclinous - a. (Gr. *monos*, single, alone; *kline*, bed) having both stamens and pistils in the same flower.
Monocotyledons - n. (Gr. *monos*, single; *kotyledon*, cup-shaped hollow) a class of angiosperms having an embryo with only one cotyledon, part of the flower usually in threes, leaves with parallel veins, and scattered vascular bundles.
Monoculture - A large group of a single species of plant.
Monoecious - a. (Gr. *monos*, single; *oikos*, house) a plant having unisexual male and female flowers on the same individual; said of a plant having unisexual flowers.
Monotypic - a. (Gr. *monos*, only; *typos*, type) a plant of only one type.
Moor - n. (ME. *mor*, fr. OE *mor*; akin MD. *moer*, mire, swamp) chiefly British: an extensive area of open rolling infertile land consisting of sand, rock, or peat usually covered with heather, bracken, coarse grass and sphagnum moss; a boggy area of wasteland usually dominated by grasses and sedges growing in a thick layer of peat.
Morphology - n. (G. *morphologie*, fr. Gr. *morph* - (fr. *morphe*, form) + G. *-logie*, -logy, more at form) a branch of biology that deals with the form and structure of animals and plants, a study of the forms, relationships, metamorphoses, and phylogenetic development of organs apart from their functions.
Mucro - n. (L. *mucro*, sharp point) a stiff or sharp point abruptly terminating an organ; a small awn.
Multipinnate - Leaf divided into several sub-groups of leaflets.
Muricate - a. (L. *muricatus*, having sharp points) having a rough surface texture owing to small, sharp projections.
Naturalize - vt. (Fr. *naturel*, natural) to adapt to an environment not native; of foreign origin, but established and reproducing as though native.
Nectar - n. (L. *nectar*, nectar; Gr. *nektar*, the drink of the gods, from base of necros, dead, dead body, and tar-, who overcomes; hence, death overcoming; so named because the drink was held to confer immortality) the sweetish liquid in many flowers used by bees for the making of honey.
Nectary - n. (Gr. *nektar*, nectar) a part of a flower that secretes nectar. pl. nectaries
Neomorphosis - n. (Gr. *neos*, new; *morphosis*, change) regeneration in cases where the new part is unlike anything in the body.
Neoteny - n. (Gr. *neos*, young; *teinein*, to extend, stretch) the retention of juvenile characteristics in the adult individual.
Neotropical - From the tropical areas of the new world (South or Central America).
Neutral flower - said of a sterile flower composed of a perianth without any sexual organs.
Node - n. (L. *nodus*, knob) a knob or joint of a stem from which leaves, roots, shoots, or flowers may arise. A node will contain one or more buds. The point on a plant stem from which the leaves and/or roots appear.
Nodose - a., nodular, knotty.
Nomenclature - n. (L. *nomen*, name; *calare*, to call) the making and giving distinguishing names to all groups of plants.
Nut - n. (ME. *nute*, *note*, fr. OE *hnute*; akin to OHG *nuz*, *hnuz*, nut) a hard-shelled dry fruit or seed having a more or less distinct separatable rind or shell and interior kernel or meat; a dry indehiscent one-seeded fruit with a woody pericarp developing from an inferior syncarpous ovary.
Nutlet - a small nut.
Oblanceolate - a. (L. *ob*, reversely; *lancea*, spear) shaped like a lance point reversed, that is, having the tapering point next to the leafstalk.
Oblique - a. (L. *obliquus*, slanting) slanting; unequal-sided.
Oblong - a. (L. *oblongus*, rather long) elliptical and from two to four times as long as broad.
Obovate - a. (L. *ob*, against; *ovum*, egg) inversely ovate; having the shape of the longitudinal section of an egg, with the broad end at the top, as some leaves.
Obovoid - a. (L. *ob*, against; *ovum*, egg; Gr. *eidos*, shape) inversely ovoid; roughly egg-shaped, with narrow end downwards; said of some fruits.
Obsolete - a. (L. *obsolescere*, to go out of use) rudimentary or not evident; applied to a structure that is almost suppressed; vestigial.

Obtuse - a. (L. *obtusus*, blunt) with blunt or rounded end.
Ocean - n. (ME. *ocean*; L. *oceanus*, fr. Gr. *okeanos*, the ocean) the great body of salt water that covers mores than two thirds of the surface of the earth; any of its five principal geographical divisions, the Atlantic, Pacific, Indian, Arctic, and Antarctic.
Ocrea - n. (L. *acrea*, greave or legging) - a tubelike covering around some stems, especially of plants of the Polygonaceae.
Odd-pinnate - said of compound leaves having an odd number of leaflets, this is usually easily determined because there is a single terminal leaflet.
Offset - Young plant growing along a stolon from the parent plant.
Oligotrophic - Deficient in nutrients needed for plant growth.
Opposite - a. (L. *opponere*, to oppose) said of leaves or bracts occurring two at a node on opposite sides of the stem. Said of flower parts when one part occurs in front of another.
Orbicular - a. (L. *orbis*, circle) round or shield-shaped with petiole attached to center.
Ovary - n. (L. *ovum*, an egg) the enlarged hollow part of a pistil in angiosperms in which ovules are formed.
Ovate - a. (L. *ovum*, an egg) having the shape of a longitudinal section of an egg; egg-shaped and attached by the broader end. Egg-shaped.
Oviparous - a. (L. *ovum*, an egg; *parere*, to produce) egg-laying; producing eggs which hatch after leaving the body of the female; germinating while still attached to the parent plant; for example, mangrove.
Ovoid - a. (L. *ovum*, an egg) egg-shaped.
Ovule - n. (L. *ovum*, an egg) a structure in seed plants which contains the megasporangium (nucellus), megaspore (embryo sac), a food store, and a coat, and develops into a seed after fertilization.
Palea - n. (L. *palea*, chaff) the upper, and usually shorter and thinner, of two membranous bracts enclosing the flower in grasses.
Palmate - a. (L. *palma*, palm) leaves divided into lobes arising from a common center.
Paludal - From a marshy or swampy environment.
Pandurate - a. (L. *pandura*, a bandore) shaped somewhat like a violin, as some leaves.
Panicle - n. (L. *panicula*, a tuft of plants) a branched racemose inflorescence often applied more widely to any branched inflorescence.
Paniculate - a., panicled; arranged or growing in panicles.
Papilla - n. (L. *papilla*, nipple) a glandular hair with one secreting cell above the epidermis level.
Papillose - a. (L. *papilla*, nipple) descriptive of a surface beset with short, blunt, rounded, or cylindrical projections.
Parenchyma - n. (Gr. *para*, besides; *enchyma*, infusion) plant tissue, generally soft and of thin-walled, relatively undifferentiated cells which may vary in structure and function.
Parietal - a. (L. *paries*, wall) when the placenta is attached to the wall of the ovary.
Peat - n. (ME. *pete*, fr. ML. *peta*, perh. of Celt. origin; akin to W. *peth*, thing - more at piece) a piece of turf cut for use as a fuel; a mass of partially carbonized plant tissue formed by partial decomposition in water of various plants and esp. of mosses of the genus Sphagnum, widely found in many parts of the world, varying in consistency from a turf to a slime used as a fertilizer, as stable litter, as a fuel, and for making charcoal.
Pectinate - a. (L. *pecten*, comb) comb-like.
Pedicel - n. (L. *pedicellus*, foot) the stalk of a flower in an inflorescence. The stem of an individual flower.
Peduncle - n. (LL. *pedunculus*, small foot) the stalk of a flower borne singly or the stalk of an inflorescence.
Peltate - a. (Gr. *pelta*, target) shield-shaped; leaves that are shaped like a shield and attached to the stem at the center or by some point distinctly within the margin, and having the petiole inserted into the undersurface of the lamina not far from the center.
Penicullate - a. (L. *penicillus*, a pencil or small brush) having the form of a pencil.
Perennation - n. (L. *perennis*, perennial) survival of a plant for a number of years. To live over from season to season.
Perennial - a. (L. *perennis*, through; *annus*, a year) a plant that grows for 3 or more years and usually flowers each year.
Perfect flower - a flower with both essential and accessory organs.
Perfoliate - a. (L. *per*, through; *folium*, a leaf) said of opposite or whorled leaves or bracts that are united into a collar-like structure around the stem that bears them.
Perianth - n. (Gr. *peri*, around; *anthos*, flower) the outer whorl of floral leaves of a flower, when not clearly divided into calyx and corolla; collectively, the calyx and corolla, or either one if one is absent.
Pericarp - n. (Gr. *peri*, around; *karpos*, fruit) the fruit wall which has developed from the ovary wall; sometimes used for any fruit covering.
Perigynium - n. (Gr. *peri*, around; *gyne*, female) fruit investing utricle of the sedges, Carex.
Perigynous - a. (Gr. *peri*, around; *gyne*, female) growing in a ring around the pistil, as the stamens; having stamens, etc. growing in this way, said of a flower.
Persistent - a. (L. *persistere*, to persist) remaining attached after the normal function has been completed.

Petal - n. (Gr. *petalon*, leaf) any of the component parts, or leaves, of a corolla; the unit of structure of the corolla.
Petaloid - a. (Gr. *petalon*, leaf; *eidos*, form) like a petal.
Petiolate - a. (L. *petiolus*, small foot) growing on, or provided with, a petiole.
Petiole - a. (L. *petiolus*, small foot) the slender stalk or stem of a leaf, also called a leaf stalk. The "stalk" attaching the leaf to the stem.
Phenotype - n. (Gr. *phainein*, to appear; *typos*, image) the characters of an organism due to the interaction of genotype and environment, a group of individuals exhibiting the same phenotypic characters. The detectable expression of the interaction of genotype and environment constituting the visible characters of an organism.
Phenotypic - a., a set of characters arising from reaction to environmental stimulus.
Phloem - n. (Gr. *phloios*, inner bark) the tissue involved in the transport of carbohydrates and food materials in a vascular plant, being composed of sieve elements, parenchyma cells and sometimes also of fibers and sclereids.
Photosynthesis - The conversion of light energy into chemical energy: carbohydrates, (sugar and starch), are produced from carbon dioxide and water through the action of light on the chlorophyll of green plants. Oxygen is released in the process.
Phyllode - n. (Gr. *phyllon*, leaf; *eidos*, form) a winged petiole with flattened surfaces placed laterally to the stem and functioning as a leaf.
Phyllotaxy - n. (L. *phyllo-*, and Gr. *taxis*, arrangement) the arrangement of the leaves on the stem. The three common positions are: alternate, opposite, and verticillate.
Phylogeny - n. (Gr. *phyle*, tribe; E. *genesis*) the racial history or evolutionary development of any plant or animal species.
Pileus - n. (L. *pileus*, cap) umbrella-shaped structure of mushrooms or toadstools.
Pilose - a. (L. *pilosus*, hairy) hairy; pubescence comprised of scattered long, slender, soft hairs.
Pinna - n. (L. *pinna*, feather) a leaflet or a primary division of a compound leaf. pl. pinnas or pinnae.
Pinnate - a. (L. *pinnatus*, feathered) divided in a feathery manner; with lateral processes of a compound leaf, having leaflets on each side of an axis or midrib.
Pinnate - Divided.
Pinnule (also pinule) - n. (NL. *pinnula*, fr. L., small feather, small fin) a secondary pinna, one of the ultimate divisions of a bipinnate or twice-pinnate leaf.
Pistil - n. (L. *pistillum*, pestle) the unit of female function of a flower, may be comprised of a single carpel or two or more carpels united.
Pistillate - n., said of a flower bearing a pistil or pistils but not stamens, may refer also to a plant having only pistillate flowers.
Pith - n. (AS. *pitha*, pith) the soft, spongy tissue, consisting of cellular tissue, in the center of certain plant stems.
Placenta - a. (L. *placenta*, flat cake) the part of the ovary from which the ovules arise. It generally occupies the whole or a portion of an angle of a cell.
Placentation - n., the manner in which the placenta is arranged in the ovary.
Plano-convex - flat on one side and convex on the other.
Plant - n. (L. *planta*, plant) any of a kingdom (Plantae) of living beings typically lacking locomotive movement or obvious sensory organs, generally making its own food, possessing cell walls, and unlimited growth.
Plantlet - n., a little plant. Plantlets that develop asexually from a parent plant: a rooted plantlet forming on a part of the mother plant.
Plicate - a. (L. *plicatus*, to fold) folded into plaits, usually lengthwise; arranged in pleats, as a fan.
Plumiform - Feather shaped.
Plumose - a. (L. *plumosus*, feather) with hairlike branches, feathery.
Pollen - n. (L. *pollen*, *pollis*, fine flour) the male or fertilizing element of seed plants, consisting of fine yellowish powder formed within the anther of the stamen.
Pollinium - n., a mass of coherent pollen characteristic of orchids and milkweeds.
Polygamo-dioecious - polygamous but chiefly dioecious.
Polygamo-monoecious - polygamous but chiefly monoecious.
Polygamous - a. (Gr. *polys*, much or many; *gamos*, marriage) having bisexual, pistillate, and staminate flowers on the same individual plant.
Polymorphic - a. (Gr. *polys*, many; *morphe*, shape) having, assuming, or occurring in various forms, characters, or styles.
Polymorphous - Having multiple shapes.
Polypetalous - a. (Gr. *polys*, many; *petalon*, a petal) with many separate petals.
Pond - n. (form of pound, enclosure) a body of standing water smaller than a lake, often artificially formed.

Pocosin - n. (Algonquian) a bog that has formed in a shallow, undrained depression, the surrounding land being somewhat elevated, the vegetation predominantly evergreen shrubs or small trees. Pocosins vary greatly in size.
Prickle - n. (ME. *prikle*, *prikel*, fr. OE. *prickle*, *pricel*; a kin to MD. *prikel*, prickle) a sharp pointed emergence arising from the epidermis or bark of a plant.
Primary production - the quantity of new organic matter created by photosynthesis.
Procumbent - a. (L. *pro*, forward; *cubare*, to lie down) trailing or lying flat but not rooting.
Production - n. (L. *producere*, to produce) the weight of new organic material formed over a period of time, plus any losses during that time period. Losses may be due to respiration, excretion, secretion, injury, death, or grazing.
Productivity - n., amount of production over a given period of time. Expressed as a rate such as g/m^2 per day, kg/ha per year, etc.
Proliferous - a. (L. *proles*, *prolis*, offspring; *ferre*, to bear) bearing supplementary structures such as buds or flowers, either in an abnormal manner or in a manner that is normal but from adventitious tissue.
Propagulum or **propagule -** n. (L. *propages*, layer of a plant) a runner or sucker used in the asexual propagation of plants. pl. propagula or propagules.
Prostrate - a. (L. *prostratus*, pp. of *prosternere*, to lay flat) growing on the ground, trailing.
Protogyny - n. (Gr. *proteros*, fore; *gyne*, female) development of the female organs before the appearance of the corresponding male products - thus inhibiting self-fertilization.
Pseudolamina - n. (Gr. *pseudes*, false; L. *lamina*, plate) the extended apical portion of a phyllode.
Pseudovivipary - n. (Gr. *pseudes*, false; L. *vivus*, alive; *parere*, to produce) a condition where vegetative propagules replace some or all of the normal sexual flowers in the inflorescence.
Pteridophyte - n. (Gr. *pteris*, fern; *phyton*, plant) a major division of the plant kingdom, having clear alternation of generations with a dominant vascular sporophyte initially dependent upon the gametophyte which is very reduced.
Puberulent - a. (L. *pubes*, adult) covered with fine, short, and nearly imperceptible down; minutely pubescent, the hairs soft, straight, erect, but scarcely visible to the unaided eye.
Pubescent - a. (L. *pubescere*, to become mature) a general term for hairiness; covered with soft hair or down.
Punctate - a. (L. *puntcum*, point) dotted; with depressed dots scattered over the surface.
Pustulate hair - a. (L. *pustulare*, to blister) hair with an enlarged base.
Pyriform - a. (L. *pyrum* or *pirum*, a pear) pear-shaped.
Raceme - A group of flowers similar to a spike, but with each individual flower on its own stem.
Raceme - n. (L. *racemus*, bunch) inflorescence having a common axis and stalked flowers in acropetel succession.
Racemose - a., an inflorescence whose growing points continue to add to the inflorescence and in which there are no terminal flowers, and the branching is monopodial, as racemes, or spikes.
Rachilla - n. (Gr. *rhachis*, spine) the zigzag center upon which the florets are arranged in the spikelet of grasses or in some sedges.
Rachis - n., the central prolongation of the stalk (peduncle), the axis through an inflorescence, or of a leaf stalk (petiole), the axis through a compound leaf.
Radially - a. (L. *radius*, a ray, a rod, a spoke) arranged, or having parts arranged, like rays; developing uniformly around a central axis.
Radially symmetrical - said of a flower or set of flower parts which can be cut through the center into equal and similar parts along two or more planes; actinomorphic.
Ramet - n. (L. *ramus*, branch) an individual member of a clone.
Receptacle - n. (L. *recipere*, to receive) the more or less expanded apex of a floral axis which bears the floral parts.
Remote - a. (L. *remotus*, to remove) separated from one another; separated by intervals or spaces greater than the ordinary.
Reniform - a. (L. *ren*, kidney; *forma*, shape) having the form or shape of a kidney.
Repent - a. (L. *repens*, crawling) said of a stem that is prostrate and rooting at the nodes.
Reticulate - a. (L. *reticulatus*, latticed) like network.
Retinaculum - n. (NL. fr. L. that which holds or binds, band, fr. *retinere*, to hold back, retain) the hook-like funicle of a seed of a plant of the family Acanthaceae; a band or band-like structure that holds an organ in place. pl. retinacula.
Retrorse - a. (L. *retrorsum*, backward) having hairs or other processes turned toward the base.
Retuse - a. (L. *retuses*, blunted) with a shallow, rounded notch at the apex.
Revolute - a. (L. *revolvere*, to roll back) said of margins that are rolled backward (toward the abaxial side).
Rhizomatous tuber - same as a corm.
Rhizome - n. (Gr. *rhiza*, a root) a subterranean horizontal root-like stem sending out leaves and shoots from its upper surface and roots from its lower surface.

Rhombus - n. (Gr. *rhombos*, object that can be turned) an outline like a rhomboid, a parallelogram with equal sides, having two oblique angles and two acute angles.
Root - n. (AS. *wyrt*, root) the part of a plant, usually below the ground, that holds the plant in position, draws water and nutrients from the soil, stores food, and is typically non-green.
Root pressure - pressure in the roots which, when the shoot is cut off, will cause liquid to secrete from the root stump; the mechanisms and tissues involved in this process are not clearly understood.
Root tuber - swollen food-storing roots.
Rootlet - n., a radicel; a little root or small branch of a root.
Rootstock - same as a rhizome.
Roseate - a. (L. *roseus*, rosy) rose-colored; rosy.
Rosette - A plant that rises from a distinct crown. A group of organs, such as leaves, clustered and crowned around a common point of attachment.
Rotate - a. (L. *rota*, wheel) shaped like a wheel; radially spreading in one plane.
Rugose - a. (L. *ruga*, a wrinkle) having or full of wrinkles; corrugated; ridged.
Rugulose - a., same as rugose.
Runcinate - a. (L. *runcina*, a plane) pinnatified, with the lobes convex before and straight behind, pointing backward, like the teeth of a saw, as in the dandelion leaf.
Runner - n. (AS. *rinnan*, to run) a specialized stolon consisting of a prostrate stem rooting at the node and forming a new plant which eventually becomes detached from the parent plant as in a strawberry plant.
Saccate - a. (L. *saccus*, bag) having the form of a sac; pouchlike.
Sagittate - a. (L. *sagitta*, arrow) shaped like the head of an arrow with the basal lobes pointing downward.
Salverform - a. (L. *salvus*, safe; *forma*, shape, figure, image) said of a corolla in which the tube is essentially cylindrical, the lobes abruptly spreading; a gamopetalous corolla.
Sarmentose - adj. (L. *sarmentosus*, fr. sarmentum, twig; plus, *-osus*, *-ose*) producing slender prostrate branches or runners.
Scabrid - a. (L. *scabridus*, rough) slightly roughened.
Scabrous - a. (L. *scabrosus*, rough) with small points or knobs, like a file; scaly, scabby, rough.
Scandent - adj. (L. *scandent-*, *scandens*, pres. part. of *scandere*, to climb - more at scan) climbing plant of a creeping or scandent nature.
Scape - n. (L. *scapus*, the shaft of a pillar, the stalk of a plant) a stem growing from the crown of the root, bearing the blossom without leaves.
Scapose - a. scape-bearing; scapigerous; consisting of a scape.
Scarious - a. (LL. *scariousus*, rough) tough, thin, dry, and semitransparent.
Schizocarp - n. (Gr. *schizein*, to cleave; *karpos*, fruit) a dry fruit, as in the maple, that splits at maturity into two or more one seeded carpels which remain closed.
Sclerenchyma - n. (Gr. *skleros*, hard; *enchyma*, an infusion) tissue of uniformly thick-walled, dead cells in the stem whose principal function is mechanical. The cells are usually grouped into fibers.
Scorpioid - a. (Gr. *skorpois*, scorpion; *eidon*, form) resembling a scorpion; said of a circinnately coiled determinate inflorescence in which the flowers are two-ranked and borne alternately at the right and left.
Secund - a. (L. *secundus*, following) arranged or growing on one side only, as flowers or leaves on a stem.
Seed - n. (AS. *saed*, seed) the part of a flowering plant that contains the embryo and will develop into a new plant if sown; a fertilized and mature ovule.
Sepal - n. (Fr. *sepale*; L. *separatus*, separate; *pelatum*, petal) any of the leaf divisions of the calyx. When a calyx consists of but one part, it is said to be monosepalous; when of two parts, it is said to be disepalous; when of a variable and indefinite number of parts, it is said to be polysepalous; and when the parts are more or less united, it is said to be gamosepalous.
Septate - n. (L. *septatus*, surrounded by a fence) having or divided by a septum or septa.
Septicidal - a. (L. *septum*, division; *caedere*, to cut or divide) dividing through middle of ovary septa; dehiscing or breaking open at a natural dividing line.
Septum - n. (L. *septum*, a partition) a partition separating two cavities or masses of tissue, as in fruits. pl. septa.
Serrate - a. (L. *serrare*, to saw) notched on edge like a saw; having sharp notches along the edge pointing toward the apex; as a serrate leaf. When a serrate leaf has small serratures upon the large ones, it is said to be double serrate, as in the elm. A serrate-ciliate leaf is one having fine hairs, like eyelashes, on the serratures. A serrate-dentate leaf has the serratures toothed.
Sessile - a. (L. *sedere*, to sit) sitting directly on base without support, stalk, pedicel, or peduncle; attached or stationary as opposed to free living or motile. A leaf that is directly attached to the plant stem with no petiole.
Seta - n. (L. *seta*, bristle) a bristle-like structure.
Setaceous - a. (L. *seta*, a bristle) bristly; set with bristles; consisting or having bristles.
Shaft - Flower-bearing stalk.
Sheath - n. (AS. *sceth*, shell or pod) a protective covering; lower part of leaf enveloping stem or culm.
Shoot - n. (ME. *schoten*, to shoot, dart) a young branch which shoots out from the main stock.

Short-day plant - a plant requiring less than 12 hours of daylight in order for flowering to occur.
Silique - n. (L. *siliqua*, a pod) the long, narrow pod of plants of the mustard family, Cruciferae, with valves which fall away from a frame bearing the seeds.
Sinuate - a. (L. *sinuare*, to bend) having a wavy margin, as some leaves.
Sinus - n. (L. a bent surface, a curve, a fold or hollow, bosom, a bay) the rounded depression between two consecutive lobes. as of a leaf. pl. sinuses, sinus.
Slough - n. (AS. *sloh*, a slough) a wet place of deep mud or mire; a sluggish channel; a swamp, bog, or marsh, especially one that is part of an inlet or backwater.
Spadix - n. (L. *spadix*, a palm branch) a racemose inflorescence with elongated axis, sessile flowers, and an enveloping spathe; a succulent spike; a fleshy spike of flowers, usually enclosed in a spathe.
Spathaceous - a., having a spathe, or having the nature of a spathe.
Spathe - Modified leaf surrounding the flower .
Spathe - n. (Gr. *spathe*, flat blade) a large leaflike part or pair of such enclosing a flower cluster (especially a spadix).
Spatulate - a., shaped like a spatula or spoon, gradually widening distally and with a rounded tip, as some leaves.
Species - n. (L. *species*, particular kind) a group of interbreeding individuals, not interbreeding with another such group, being a taxonomic unit including two names in binomial nomenclature, the generic name and specific epithet, similar and related species being grouped into a genus.
Spermatophyta - n. (Gr. *sperma*, seed; *phyton*, plant) a major division of the plant kingdom, characterized by reproducing by seed and subdivided into the Gymnospermae and Angiospermae.
Spicate - a. (L. *spicatus*, pp. of *spicare*, to furnish with spikes) having the form of a spike.
Spicule - n. (L. *spicula*, a small spike) a small, slender, sharp-pointed piece, usually on a surface; a small spike of flowers.
Spike - n. (L. *spica*, spike, ear of corn) a long flower cluster attached directly to the stalk. A group of flowers arranged closely at the end of a shaft, and attached directly to the shaft.
Spikelet - n., a small spike of a large one; a subdivision of a spike; as the spikelets of grasses.
Spine - n. (ME, *thorn*, spinal column, fr. L. *spinsa*, thorn, spine, spinal column) a stiff sharp-pointed plant process as a modified leaf, leaf part, petiole, or stipule.
Sporangium - The reproductive organ of primitive plants like ferns and mosses.
Spore - n. (Gr. *sporos*, seed) any of various small reproductive bodies, often consisting of a single cell, produced by mosses, ferns, etc. asexually (asexual spore) or by the union of gametes (sexual spores); they are highly resistant and are capable of giving rise to a new adult individual, either immediately or after an interval of dormancy.
Sporophyte - n. (Gr. *sporo*, a seed; *phyton*, plant) the diploid spore-producing phase in plants with alternation of generations.
Spur - n. (AS. *spura*, *spora*, a spur) a slender, tubelike structure formed by an extension of one or more petals or sepals; also refers to a very short branch with closely spaced leaves.
Stalk - n. (probably from Dan. *stilk*; Sw. *stjelk*; Icel. *stilker*, a stalk) the stem or main axis of a plant, which supports the leaves, flowers, and fruit. Any lengthened support on which an organ grows, as the petiole of a leaf or the peduncle of a flower.
Stamen - n. (L. *stare*, to stand) the male reproductive organs in flowers; it is situated immediately within the petals, and is composed, in most cases, of two parts, the filament, and the anther, which is filled with pollen.
Staminate - a., producing or consisting of stamens; flowers with stamens but not pistils.
Staminodium - n. (L. *stamen*, a thread, and Gr. *eidos*, form) a sterile stamen or an organ resembling one.
Standing crop - weight or organic material that can be sampled or harvested at any one time from a given area, but may not necessarily include the entire plant. Usually refers to normal harvesting procedures, unless specified, for the particular plant under consideration.
Stellate - a. (L. *stella*, star) starlike; said of hairs that branch in such a manner as to radiate from a central point.
Stem - n. (AS. *stemm*, tree stem) main axis of a plant typically above the soil surface, having leaves or scales, and a characteristic arrangement of the vascular tissue.
Stem tuber - swollen structures produced by stolons and runners which remain dormant during adverse conditions and later grow into new plants when the conditions become favorable for growth.
Stigma - n. (Gr. *stizein* to prick) the upper tip or part of the pistil of a flower receiving the pollen. It is generally situated at the upper extremity of the style.
Stipe - n. (L. *stipes*, stalk) the stalk-like basal part of an ovary, or of a fruit such as an achene; the stem bearing pileus in mushrooms and toadstools.
Stipel - n., a small secondary stipule at the base of a leaflet.
Stipule - n. (L. *stipula*, a stalk, a straw) one of two foliaceous or membranaceous processes developed at base of a leaf petiole, sometimes in tendril or spine form, sometimes fused.

Stolon - n. (L. *stole*, *stolonis*, a twig, shoot) a stem which grows from a stem above the ground, taking root at the tip, and ultimately developing a new plant.
Stoma - n. (NL. fr. Gr. mouth - more at stomach) one of the minute openings in the epidermis of leaves, stems, and other plant organs through which gaseous interchange between the atmosphere and the intercellular spaces within these structures occur; the opening together with its associated guard cells and accessory cells. pl. stomata.
Stramineus - a. (L. *stramen*, straw) of or like straw; straw-colored.
Striated - a. (L. *striatus*, grooved) marked by narrow lines or grooves, usually parallel.
Strigose - a. (L. *striga*, a furrow) covered with stiff hairs; ridged; marked by small furrows; surface clothed with stiff, often appressed hairs, these usually pointing in one direction.
Style - n. (Gr. *stylos*, pillar; L. *stylus*, pricker) slender upper part of pistil, supporting stigma.
Stylopodium - n. (Gr. *stylos*, pillar; *pous*, foot) the fleshy support at the base of the style in flowers of the carrot family, Umbelliferae.
Submerge - vt. (L. *submergere*, to dip or plunge under) to sink or plunge beneath the surface of water.
Submersed - Growing completely underwater.
Submersed plants - plants growing with their root, stems, and leaves completely under the surface of the water.
Suborbicular - adj. (L. *sub*, under, below; *orbis*, circle) approximately circular.
Subulate - a. (L. *subula*, an awl) awl-shaped; slender and tapering gradually to a fine point.
Succulent - n. (L. *succus*, juice) juicy; full of juice or sap.
Suffruticulose - a. (L. *sub*, under, below; *frutex*, a shrub) moderately frutescent; obscurely shrubby; usually woody only basally.
Sulcate - a. (L. *sulcus*, a furrow) furrowed, grooved; scored with deep, parallel furrows or grooves.
Suture - n. (L. *suere*, to sew) a seam formed when two parts unite; a seam or line or groove; usually applied to the line along which a fruit dehisces; any lengthwise groove that forms a junction between two parts.
Swale - n. (Sw. *sval*, cool) a hollow or depression, especially one in wet, marshy ground.
Swamp - n. (Sw. *svampig*, swampy) spongy land; low ground filled with water; a wooded area having surface water much of the time.
Sympodial - a. (Gr. *syn*, with; *pous*, foot) branching, growth of axillary shoots when apical budding has ceased.
Syncarp - n. (Gr. *syn*, together; *karpos*, fruit) a multiple or aggregate fruit derived from numerous separate ovaries of a single flower; a collective unit, as a blackberry.
Syntepalous - flowers in which the sepals are fused.
Taenia - n. (Gr. *tainia*, a ribbon or tape) formation of ribbon-like structure with little or no differentiation between the leaf blade and stem.
Tannins - n. (L. *tannum*, oak bark) complex aromatic compounds some of which are glucosides, possibly giving protection or concerned with pigment formation.
Taxon - n. (Gr. *taxis*, arrangement) a taxonomic category or unit, as a species or genus.
Taxonomy - n. (Gr. *taxis*, arrangement; *nomos*, law) a science that includes identification, nomenclature, and classification of objects, and is usually restricted to objects of biological origin; orderly classification of plants according to their presumed natural relationships forming a basic biological discipline involving during its Linnean period the firm establishment of binomial nomenclature and acceptance of the static concept of fixity of the species, during its Darwinian period the dynamic concept of speciation by natural selection, and during its modern Mendelian epoch an expansion to include study of the mechanisms underlying speciation and related processes.
Tendril - n. (O.Fr. *tendrillon*, tender sprig) a slender twining or clasping process, modified stem, leaf, or part of a leaf, by which some plants climb.
Tepal - n. (Fr. *tepale*, from petale) denoting a unit of the perianth when the sepals and petals are essentially alike and not readily differentiated.
Terete - a. (L. *teres*, round, smooth) nearly cylindrical in cross-section, as stems.
Ternate - a. (L. *terni*, three each) growing in groups of threes, as some leaves.
Testa - n. (L. *testa*, shell) the hard outer covering or integument of seed.
Thalloid - a., of or resembling a thallus.
Thallophyta - n. pl. (Gr. *thallos*, a young shoot; *phyton*, a plant) a primary division of plants including all forms consisting of one cell and cell aggregates not clearly differentiated into root, stem, and leaf, including bacteria, algae, fungi, and lichens.
Thallus - n. (Gr. *thallos*, a young shoot) a plant body that lacks differentiation into distinct forms of stems, leaves, roots, and does not grow from an apical point.
Therophytes - n. (Gr. *theros*, summer; *phyton*, a plant) an annual plant that overwinters as a seed.
Thorn - n. (ME., fr. OE.; akin to OHG. *dorn*, thorn, ON. *thorn*, Goth. *thaurnus*, thorn, Skt. *trna*, grass, blade of grass) a sharp rigid process on a plant; specif., a short, indurated, sharp-pointed, and leafless branch developed from a bud in a manner typical to a leafy branch.

Throat - n. (Gr. *drossel*, the gullet) term applied to an expanded part of a corolla tube just below the lobes.
Thyrseus - n. (Gr. *thyrsos*, wand) a panicle-like inflorescence consisting of a slender indeterminate main axis with lateral axes determinate, i.e., cymose.
Tiller - n. (OE. *telgor*, *telgra*, branch, twig, shoot) sprout, stalk, especially one from the base of a plant or from the axils of its lower leaves.
Tissue culture - The production of new plants from small amounts of plant tissue under carefully controlled laboratory conditions. The use of specialized methods to mass produce plants starting with small amounts of plant tissue.
Tomentose - a. (L. *tomentum*, down) densely covered with short, matted hair.
Tracheophyta - n. (LL. *trachia*, windpipe; and Gr. *phyton*, plant) a division of plants comprising green plants with a vascular system that contains tracheids or tracheary elements, being the Pteridophyta and Spermatophyta, commonly called vascular plants.
Trichome - n. (Gr. *trichoma*, a growth of hair) an outgrowth of the plant epidermis, either hairs or scales; a hair tuft; any hairlike outgrowth of the epidermis.
Trigonal - a. (Gr. *trigonos*, triangular) triangular in cross-section as applied to stems.
Trigonous - a., trigonal; having three prominent longitudinal angles, as a style or ovary.
Trimerous - a. (Gr. *tria*, three; *meros*, part) composed of three or multiples of three.
Triploid - n. (Gr. *triplus*, triple) having or being a chromosome number three times the monoploid number.
Triquetrous - a. (L. *triquetrus*, three-cornered) triangular; having a triangular cross section.
Tristichous - a. (Gr. *tria*, three; *stichos*, row) arranged in three vertical rows.
Truncate - a. (L. *truncatus*, cut off) terminating abruptly, as if tapering end were cut off; cut squarely across, either at the base or apex of an organ.
Trunk - n. (OFr. *trone*; fr. L. *truncus*, a trunk, stock, stem) the main stem or body of a tree, considered apart from its roots and branches.
Tuber - n. (L. *tuber*, a swelling or knob on plants) the short, thickened fleshy food-storing portion of an underground stem with many surface buds, generally shaped like a rounded protuberance. A swelling of root or underground stalk that functions as a storage organ as in a potato.
Tubercle - n. (L. *tuberculum*, a swelling) a small rounded protuberance; root swelling or nodule; bubil; a surficial nodule; a thickened, solid, spongy crown or cap, as on an achene; a small tuber or tuberlike growth.
Turbinate - a. (L. *turbinatus*, whirl, rotation) inversely conical; shaped like a cone resting on its apex.
Turion - n. (L. *turio*, shoot) young scaly shoot budded off from underground stems, detachable winter bud used for perennation in many aquatic plants.
Twig - n. (AS. *twigge*, twig) a small shoot or branch of a tree or other plant.
Umbel - n. (L. *umbella*, dim. of *umbra* shadel) an arrangement of flowers springing from a common center and forming a flat or rounded cluster.
Umbellate - a., bearing umbels; consisting of umbels; forming an umbel or umbels.
Unisexual - a. (L. *unus*, one; *sexus*, sex) of one or other sex, staminate or pistillate only, but not both.
Urceolate - a. (L. *urceolus*, a pitcher) shaped like a pitcher or urn.
Utricle - n. (L. *utriculus*, a little bag or bottle) an air bladder of aquatic plants; membranous indehiscent 1-celled fruit.
Valvate - adj. (NL. *valvatus*, fr. L., having folding doors) meeting at the edges without overlapping; opening as if by doors or valves.
Variety - n. (L. *varietas*, variety) a taxonomic group below the species used in different senses by different specialists, including a race, stock, strain, breed, subspecies, geographical race, or mutant.
Vascular bundle - a group of specialized cells consisting of xylem and phloem, sometimes separated by a strip of cambium and arranged in different patterns.
Vascular cambium - lateral meristem that forms the secondary tissue and is located between the xylem and phloem.
Vegetative cone - Growing tip of the plant. On a stem plant, it is the tip of the stem. On a rosette plant, it arises from the very center of the rosette.
Vegetative reproduction - Reproduction via means other than sexual. Unless a mutation occurs, each generation of new plants is identical to the parent plant genetically.
Velamen - n. (L. *velamen*, covering) a membrane; water-storing tissue in the outer layer of some roots.
Vernal - a. (L. *vernalis*, of the spring) belonging to the spring; appearing or occurring in spring; of the spring season.
Verrucose - a (L. *verrucosus*, full of warts, warty) warty; having little warts or wartlike growth on the surface.
Versatile - a. (L. *versatillis*, turning around) turning freely on its support, as an anther attached near the middle and capable of swinging freely on the filament.
Verticil - n. (L. *verticillus*, whorl) an arrangement of leaves, flowers, inflorescences, or other structures which surround the stem in a circle upon the same plane about the same point on the axis.
Verticillate - a. (L. *verticillus*, whorl) growing in a whorl or arranged on the same plane around an axis, as flowers, leaves, branches, etc.; arranged in verticils, whorled.

Vesicle - a. (L. *vesicula*, bladder) any small bladderlike structure, cavity, sac, or cyst; a small bladderlike sac filled with air.
Vestiture - n. (L. *vestitus*, grament) that which covers a surface, as hairs, scales, etc.
Villous - n. (L. *villosus*, hairy) pubescent; shaggy; covered with fine long hairs, but the hairs not matted.
Viscid - a. (L. *viscum*, bird lime) thick, syrupy, and sticky; viscous; covered with a viscid substance as of leaves.
Viviparous - a. (L. *vivus*, alive; *parere*, to produce) producing young alive rather than in eggs, as in most mammals; multiplying by vegetative means such as buds or bulbils in the position of flowers.
Wet weight - same as fresh weight; weight of plants after the outer surface covering of water has been removed. Wet weight is not a reliable measurement since methods to prepare plants prior to weighing vary considerably.
Wet woodland - a wooded area having surface water some of the time, for intermittent short periods.
Whorl - n. (AS. *hweorfan*, to turn) circle of flowers, parts of a flower, or leaves arising from one point; verticil.
Whorled - a., when three or more leaves are arranged at the same level on a stem, typical of such plants as hydrilla.
Woody - a. (ME. *woddy*, *wody*, fr. *wode*, wood + -y) of or containing wood or wood fibers; consisting mainly of hard lignified tissues.
Xeric - a. (Gr. *xeros*, dry) characterized by a scanty supply of moisture, tolerating, or adapted to, arid conditions.
Xylem - n. (Gr. *xylon*, wood) woody tissue that is part of the water-transporting system in plants, consisting of lignified tracheids or vessels, and which also acts as a supporting tissue.
Yield - n. (AS. *glidan*, to pay, restore, give up) standing crop expressed as a rate, i.e., g dry weight per meter square per day.
Zygomorphic - a. (Gr. *zygon*, yoke; *morphe*, shape) said of the corolla or calyx when divisible into equal halves in one plane only bilaterally symmetrical, with only one plane of symmetry.

Post Quiz Answers

Weed Identification Section Topic 1 Answers
1. Annual weeds, 2. Summer annuals, 3. Summer annuals, 4. Plants non-native, 5. Native species, 6. Extinct, 7. Linear-, egg-, round- or butterfly, 8. Thin, less vigorous turf given insufficient water, 9. Buckwheat family, 10. Asclepias family

Invasive Plant Species Introduction Topic 2 Answers
1. New habitat, 2. Eurasian watermilfoil, 3. Autumn olive, 4. Canada thistle (Cirsium arvense), 5. Dalmatian toadflax, 6. Similar rhizomes, 7. Leafy spurge (Euphorbia esula L.), 8. Russian thistle, 9. Scotch thistle, 10. Spurge laurel

Commonly Found Invasive and/or Noxious Weeds - Topic 3 Answers
1. Overwinter, 2. Musk thistle, 3. Seed output, 4. Canada thistle, 5. Biological control, 6. Chinese lespedeza, 7. Downy pubescence, 8. Fountain grass, 9. Figwort family, or Scrophulariaceae, 10. Highly flammable

Herbs and Related Invasive Species Topic 4 Answers
1. Genetic resistance, 2. Weed control, 3. Herbicide-resistant weeds, 4. Desirable native species, 5. Late in the growing season, 6. Rhizomatous, perennial herb, 7. A warm-season, perennial bunch grass, 8. Contact herbicides, 9. 2,4-D and MCPP, 10. Postemergence herbicide

Vine Section Alien Plant Invaders Topic 5 Answers
1. Akebia, 2. Porcelainberry, 3. Oriental bittersweet, 4. Climbing euonymus, 5. English ivy, 6. English ivy, 7. Japanese honeysuckle, 8. Mile-a-minute, 9. Kudzu, 10. Buffalo Gourd

Trees- Alien Plant Invaders Topic 6 Answers
1. Ailanthus, 2. Princess tree, 3. Princess tree, 4. Silk tree, 5. Australian pine, 6. Carrotwood, 7. White poplar, 8. Common buckthorn and glossy buckthorn (*Rhamnus frangula*), 9. Buckthorn seedlings, 10. Castor oil plant

Weed Management and Control Section Topic 7 Answers
1. Phytotoxicity, 2. Mechanical and chemical controls, 3. Biological controls, 4. Cultural Control, 5. Opportunistic, 6. A nonselective, quick-acting herbicide, 7. Systemic herbicide, 8. Targeted plants, 9. Persistence, 10. Half-life

Introduction to Wetlands Section Topic 8 Answers
1. Water hyacinths, 2. Yellow snapdragon like flowers, 3. Water lettuce, 4. 2,4-D compounds, 5. Renovate, 6. Reward, 7. Plant enzyme AHAS (acetohydroxyaced synthase), 8. Liquid glyphosate formulations, 9. Systemic herbicides, 10. Imazapyr

Submersed Aquatic Weed Section Topic 9 Answers
1. Contact herbicides, 2. Liquid diquat formulation, 3. Triclopyr, 4. Copper compounds, 5. Both liquid and granular formulations, 6. Systemic herbicides, 7. Egeria, elodea, or hydrilla, 8. Calcium and magnesium, 9. Soft water, 10. Heavy metals

Aquatic Herbicides and Controls Section Topic 10 Answers
1. Desiccant, 2. Water soluble, 3. Broad-spectrum, nonselective systemic herbicide, 4. Salt form, 5. Spot treatment, 6. Fluridone, 7. Very low concentrations of copper sulfate, 8. Crop and non-crop irrigation, 9. An essentially dust free material for easier application 10. Restrictions on water usage

Invasive Plant Rule Section Topic 11 Answers

1. Invasive species, 2. A non-native plant, 3. Invasive plants, 4. Desirable plant species, 5. Federal Environmental Pesticide Control Act of 1972, 6. Responsible for the effects of pesticide residues, 7. Prolonged chemical contact with skin, 8. Velocity of the wind, 9. Rate of application to the target area, 10. Broad-leaved weeds in crops

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