COLORADO STATE PARKS
STEWARDSHIP PRESCRIPTION

Aquatic Herbicide Management

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Parks Affected: All parks

ATTENTION! IMPORTANT!!! PLEASE READ:

1. **Listing of products in this document does not constitute a guarantee or warranty of the products named and does not signify that these products are approved to the exclusion of comparable products.**

2. **Should the registration of an herbicide or certain uses of an herbicide be canceled by federal or state agencies, recommendations thus affected herein are no longer applicable after such action is taken.**

3. **Before using any pesticide, be sure it is registered for use in your locality.**

4. **It is the responsibility of persons intending to use a pesticide to read and follow the label that has been approved for the particular state or locality in which the pesticide is to be used, and to comply with all federal, state, and local laws and regulations relating to the use of pesticides.**

5. **The recommendations included in this document represent the opinions of the author and are based on research done using the best available information at the time.**

6. **The regulatory information within this document represents the best information available from officials of regulatory agencies at the time of the writing of the document. Because rules, regulations, and laws as well as their interpretation may change over time, it remains the responsibility of the user of this document to ensure that all legal requirements are met.**

7. **Every attempt has been made to identify all relevant laws that may apply, but no guarantee is made to this effect.**

INTENT – What do I need to know about using herbicides in aquatic and wetland situations?

The primary goal of this prescription is to inform and advise state park managers and staff on the safe and legal use of herbicides in aquatic and wetland situations. Specifically, this prescription will discuss:

- Which herbicides are registered for use in wetter areas in the state of Colorado
- The mode of action of each herbicide
- Target noxious weed species for each herbicide
- Ecological toxicity of each herbicide (when known)
- Human toxicity of each herbicide
- Which chemicals are known to contaminate groundwater supplies
- Alternatives to herbicide use
- Regulations that apply to herbicide use in Colorado

ISSUE – Why is it important to be knowledgeable before using herbicides in aquatic and wetland situations?

- EPA registers herbicides for specific uses only. It is illegal to use an herbicide for unlabeled purposes.
- Improper use can result in unintentional damage to non-target plants or animals.
- Even proper use of a product can cause fish kill. It is important to know the potential consequences of the use of any herbicide.
- Water use restrictions may apply after application of herbicides.
- The federally listed threatened Preble's meadow jumping mouse lives in riparian areas. Consequently, herbicide application in such areas may impact this protected species.

ADVANTAGES AND DISADVANTAGES TO USING AQUATIC HERBICIDES –

Advantages

- Aquatic herbicide application can be less expensive than other aquatic plant control methods.
- Aquatic herbicides are easily applied around docks and underwater obstructions.
- Aquatic herbicides can be applied directly to problem areas of all sizes.

Disadvantages

- Some herbicides have swimming, drinking, fishing, irrigation, and water use restrictions.
- Herbicide use may have unwanted impacts to people who use the water and to the environment.
- Non-targeted plants in addition to nuisance plants may be damaged or killed by some herbicides.
- Rapid-acting herbicides like Aquathol® may cause low oxygen conditions to develop as plants decompose. Low oxygen can cause fish kills.

- Some expertise and training in using herbicides is necessary in order to be successful and to avoid unwanted impacts.
- Many people have strong feelings against using chemicals in or near water. This is relevant when applying herbicides in public waters.

HERBICIDES – What is an Herbicide?

An herbicide is a pesticide, a substance defined by The United States Environmental Protection Agency (EPA) as an agent used to prevent, destroy, repel or mitigate *any pest* ranging from insects, animals and weeds to microorganisms such as fungi, molds, bacteria and viruses (http://www.epa.gov/ebtpages/pesticides.html). An herbicide, then, is any compound capable of killing or severely injuring plants and may be used for the elimination of plant growth or the killing off of plant parts (Amdur et al, 1991).

In accordance with provisions in The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), ***a pesticide cannot be used legally in the United States if it has not been registered with EPA's Office of Pesticide Programs***. In Colorado, not only must a pesticide be registered with EPA, but it must also be registered with the state before it can be distributed and used. The Colorado State Department of Agriculture, Division of Plant Industry, handles pesticide registration in accordance with the Colorado Pesticide Act (Article 9, Title 35, Colorado Revised Statutes). Their website has a database which allows users to search online for pesticide products to determine whether or not a product is registered for use in the state of Colorado.
http://www.ag.state.co.us/DPI/Pesticides/PPRS/PPRSQuery.htm

The EPA registers an herbicide product for either general use or restricted use. Classification depends upon the impact of the herbicide application on the environment and human health. Herbicides that generally do not cause unreasonable adverse effects on the environment and human health, *when used as directed*, are classified for general use. Herbicides that, under the same circumstances, are more likely to cause injury to the applicator or have other adverse impacts are classified as restricted-use pesticides.

The label on a pesticide details how to legally use the product. Any variation from the explicit instructions on the label is a violation of law.

For a restricted use pesticide (RUP), in addition to all legal requirements on the label, its use and sale is further restricted. It may be sold *only* by a dealer licensed as a Colorado Restricted Use Pesticide Dealer, and may only be applied by certified applicators (Contact the Colorado State Department of Agriculture for questions on this issue). Any herbicide designated as a RUP by the EPA will automatically be a RUP in Colorado. However, the state may designate any EPA general use pesticide as a RUP in Colorado.

Table 1 lists the known herbicides currently registered for use in Colorado in aquatic and/or wetland situations. **All herbicides listed in Table 1 are general use products.**

Table 1. Herbicides registered in Colorado for use in aquatic and/or wetland situations*

Active Ingredient	Product	Manufacturer	Registered Uses
			NA = NOT FOR AQUATIC USE, see allowed uses**
Aquatic Dye Product			
Acid blue 9, Acid yellow 23	Aquashade	Applied Biochemists	Aquatic use: natural and manmade contained lakes and ponds
Copper Products			
Copper	Clearigate	Applied Biochemists	Aquatic use: irrigation and drainage canals, ponds, lakes
Copper	Cutrine-Plus	Applied Biochemists	Aquatic use: lakes, potable water reservoirs, fish and industrial ponds, crop and non-crop irrigation conveyance systems, ditches, canals and laterals
Copper	Komeen Aquatic	Griffin, LLC	Aquatic use: slow moving or quiescent bodies of water including: golf course, ornamental, fish or fire ponds, fresh water lakes, fish hatcheries and potable water reservoirs
Copper	Nautique Aquatic	SePRO Corporation	Aquatic use: still or flowing aquatic sites such as potable water sources, lakes, rivers, reservoirs or ponds, slow flowing or quiescent water bodies, crop and non-crop irrigation systems, fish, golf course, ornamental, swimming and fire ponds, and aquaculture including fish and shrimp.
Diquat Product			
Diquat dibromide	Reward	Syngenta Crop Protection, Inc	Aquatic, Drawdown zones, Edges of ponds, lakes, ditches. Aquatic use: ponds, lakes reservoirs, drainage ditches, streams, rivers
Endothall Products			
Dipotassium salt of endothall	Aquathol K	Cerexagri, Inc.	Aquatic use: irrigation and drainage canals, ponds, lakes
Dipotassium salt of endothall	Aquathol Super K	Cerexagri, Inc.	Aquatic use: ponds, lakes
Amine salt of endothall	Hydrothol 191	Cerexagri, Inc.	Aquatic use: irrigation and drainage canals, ponds, lakes
Amine salt of endothall	Hydrothol 191 Granular	Cerexagri, Inc.	Aquatic use: irrigation and drainage canals, ponds, lakes
Fluridone Products			
fluridone	Avast! Aquatic	Griffin LLC	Aquatic use: ponds, lakes, reservoirs, irrigation and drainage canals
fluridone	Avast! SRP	Griffin LLC	Aquatic use: ponds, lakes, reservoirs, irrigation and drainage canals, rivers
fluridone	Sonar A.S.	SePRO Corporation	Aquatic use: ponds, lakes, reservoirs, potable water sources, drainage and irrigation canals

Table 1 Continued

Active Ingredient	Product	Manufacturer	Registered Uses
fluridone	Sonar PR	SePRO Corporation	Aquatic use: ponds, lakes, reservoirs, potable water sources, drainage and irrigation canals
fluridone	Sonar SRP	SePRO Corporation	Aquatic use: ponds, lakes, reservoirs, potable water sources, drainage and irrigation canals, rivers
Pelargonic Acid Product			
Pelargonic acid	Scythe	Mycogen Corporation	**NA**-Drawdown zones, Dry ditches, Dry canals, Around aquatic sites above water line. Do not apply directly to water or wetlands.
Triclopyr Products			
Triethylamine salt of triclopyr	Garlon 3A	Dow AgroSciences LLC	**NA**-Wetland (w/conditions), Non-irrigation ditchbanks, Seasonally dry wetlands, Marshes, Floodplains, Transitional areas between upland and lowland sites
Butoxethyl ester of triclopyr	Garlon 4	Dow AgroSciences LLC	**NA**-Wetland (w/conditions), Non-irrigation ditchbanks, Seasonally dry wetlands, Marshes, Floodplains, Transitional areas between upland and lowland sites
Triethylamine salt of triclopyr	Renovate 3	SePRO Corporation	Aquatic, Wetland, Marshes, Wetlands, Shores within or adjacent to aquatic sites Aquatic use: ponds, lakes, reservoirs, non-irrigation canals and ditches with little or no continuous outflow
Glyphosate Products			
Isopropylamine salt of glyphosate	Accord	Dow AgroSciences LLC	Aquatic, Riparian, Wetland, Wet meadow, Draw down zone, In and around aquatic areas and wetlands found in forestry and in power, telephone and pipeline rights-of-way sites, including where these sites are adjacent to or surrounding domestic water supply reservoirs, supply streams, lakes and ponds.
Isopropylamine salt of glyphosate	Aquamaster	Monsanto Company	Aquatic, Riparian, Wetland, Wet meadow, Draw down zone. This product may be applied to emerged weeds in all bodies of fresh and brackish water which may be flowing, non-flowing or transient. This includes lakes, rivers, streams, ponds, estuaries, seeps, irrigation and drainage ditches, canals, reservoirs, wastewater treatment facilities, wildlife habitat restoration area, and similar sites.
Isopropylamine salt of glyphosate	Aquaneat	Nufarm Americas Inc.	Aquatic, Riparian, Wetland, Wet meadow, Draw down zone. This product may be applied to emerged weeds in all bodies of fresh and brackish water which may be flowing, non-flowing or transient. This includes lakes, rivers, streams, ponds, estuaries, seeps, irrigation and drainage ditches, canals, reservoirs, wastewater treatment facilities, wildlife habitat restoration, and similar sites.

Table 1 Continued

Active Ingredient	Product	Manufacturer	Registered Uses
Isopropylamine salt of glyphosate	Eagre Aquatic	Griffin LLC	Aquatic, Riparian, Wetland, Wet meadow, Draw down zone. This product may be applied to emerged weeds in all bodies of fresh and brackish water which may be flowing, non-flowing or transient. This includes lakes, rivers, streams, ponds, estuaries, seeps, irrigation and drainage ditches, canals, reservoirs, wastewater, treatment facilities, wildlife habitat restoration area, and similar sites.
Isopropylamine salt of glyphosate	Glyphosate VMF	E.I. duPont de Nemours & Co., Inc.	Aquatic, Riparian, Wetland, Wet meadow, Draw down zone, In and around aquatic areas and wetlands found in forestry and in power, telephone and pipeline rights-of-way sites, including where these sites are adjacent to or surrounding domestic water supply reservoirs, supply streams, lakes and ponds. Product may be applied to emerged weeds, woody brush, and trees, in all bodies of fresh and brackish waters that may be flowing, non-flowing or transient.
Isopropylamine salt of glyphosate	Glypro	Dow AgroSciences LLC	Aquatic, Riparian, Wetland, Wet meadow, Draw down zone. This product may be applied to emerged weeds in all bodies of fresh and brackish water which may be flowing, non-flowing or transient. This includes lakes, rivers, streams, ponds, estuaries, seeps, irrigation and drainage ditches, canals, reservoirs, wastewater, treatment facilities, wildlife habitat restoration area, and similar sites.
Isopropylamine salt of glyphosate	Rodeo	Dow AgroSciences LLC	Aquatic, Riparian, Wetland, Wet meadow, Draw down zone. This product may be applied to emerged weeds in all bodies of fresh and brackish water which may be flowing, non-flowing or transient. This includes lakes, rivers, streams, ponds, estuaries, seeps, irrigation and drainage ditches, canals, reservoirs, wastewater, treatment facilities, wildlife habitat restoration area, and similar sites.
2,4-D Products			
Butoxethylester of 2,4-D	Navigate	Applied Biochemists	Aquatic-no further detail provided on label.
Dimethylamine salt of 2,4-D	Savage Dry Soluble	UAP – Platte Chemical Company	Aquatic and Irrigation canal ditchbanks. Aquatic use: ponds, lakes, reservoirs, marshes, drainage ditches, canals, rivers, and streams that are quiescent or slow moving.
Dimethylamine salt of 2,4-D	Solution Water Soluble	Riverdale	Aquatic, Rights of way, Drainage ditchbanks, Irrigation canal ditchbanks, Shorelines
Dimethylamine salt of 2,4-D	Weedar 64	Nufarm Americas Inc.	Aquatic and Irrigation canal ditchbanks. Aquatic use: ponds, lakes, reservoirs, marshes, drainage ditches, canals, rivers and streams that are quiescent or slow moving,

*As of April 2003

**Aquatic use means the product may be applied directly into a body of water for control of submersed or floating weeds or may be applied over a water body to control floating mats of vegetation.

MODES OF ACTION OF HERBICIDES – How do herbicides work?

Herbicides may be divided into two types: pre-emergence herbicides and post-emergence herbicides.

Pre-emergence herbicides are applied to soil, and they prevent the growth and development of most germinating seeds (weeds as well as desirable plants) by inhibiting plant cell division (Ross and Childs, 1996).

Post-emergence herbicides are applied to foliage *after* a plant has already germinated and is actively growing or mature. All of the herbicides in Table 1 are used primarily as post-emergence herbicides. Post-emergence herbicides are also called foliar applied herbicides, and they act to kill and injure plants using several different mechanisms of action (Ross and Childs, 1996).

Post-emergent herbicides function by disrupting one or more of the vital processes that occur within plant cells. Examples of these vital metabolic plant processes include photosynthesis (capture of light energy and carbohydrate synthesis), amino acid and protein synthesis, fat synthesis, pigment synthesis, nucleic acid synthesis (RNA and DNA), respiration (metabolism of sugars to provide usable energy for the plant), and maintenance of membrane integrity. Other vital processes include growth and differentiation, mitosis (cell division) in plant meristems, and meiosis (division resulting in gamete and seed formation) (Ross and Childs, 1996).

Some herbicides are mobile and they move from the application site to other parts of the plant where they act to kill or damage the plant. Other herbicides act almost immediately at the point of contact (Ross and Childs, 1996). Still other herbicides act via an indirect mechanism. Table 2 lists the modes of action of the herbicides listed in Table 1.

Mobile Herbicides

Amino acid inhibitors:
Amino acid synthesis inhibitors act on a specific enzyme to prevent the production of specific amino acids, the key building blocks for normal plant growth and development. In general, injury symptoms are slow to develop (1 to 2 weeks) and include stunting or delayed plant growth that leads to eventual death of the plant (University of Minnesota, 1998).

Auxin growth regulators:
Auxin is a natural plant hormone necessary for normal plant growth. Auxin growth regulators act as auxin mimics, and they cause a variety of plant growth abnormalities. These herbicides are selective against broadleaf weeds but are capable of injuring grass species. The herbicides are quickly translocated to areas of new plant growth making them very effective against annual and perennial broadleaf weeds. Herbicide uptake is primarily through the leaves but root uptake is also possible. Injury symptoms are most obvious on newly developing leaves (University of Minnesota, 1998). These herbicides cause injury because plants cannot readily control the concentration of synthetic auxins applied in relatively high doses like they can control natural auxin levels (Gibson, 2001).

Photosynthesis inhibitors:

Photosynthesis inhibitors may directly shut down the photosynthetic (food producing) process in susceptible plants by binding to specific sites within the plant chloroplast where photosynthesis occurs (North Dakota State University, 1994).
Other herbicides inhibit the formation of pigments necessary for photosynthesis (Ross and Childs, 1996). When these pigments are not produced, ultimately the plant will not be able to photosynthesize. Inhibition of photosynthesis could result in a slow starvation of the plant; however, in many situations rapid death occurs perhaps from the production of secondary toxic substances (North Dakota State University, 1994).

Contact Herbicides

Cell membrane destroyers:
Herbicides in this family are postemergence contact herbicides that are activated by sunlight to form active compounds that disrupt the plant cells causing disintegration of cell membranes and chloroplasts. Destruction of cell membranes results first in rapid desiccation of plant foliage (wilting), followed by necrosis, and eventual death of the plant. On bright sunny days herbicide injury symptoms can occur in one to two hours (University of Minnesota 1998). The rapid disruption of the cell membranes prevents movement of the herbicide to other regions of the plant (Ross and Child 1996).

Indirect Acting Herbicides

Aquatic dye:
A blend of blue and yellow dyes specifically designed to screen or shade portions of the sunlight spectrum (red-orange and blue-violet) required by underwater aquatic plant and algae growth. This action effectively inhibits photosynthesis in young, bottom growth and may prevent development altogether if applied early enough in the season.

Some of the products described in this document require the use of a surfactant in order to be effective. Read the label to understand exactly how the product must be used.

Table 2. Mode of action of listed herbicides*

Active Ingredient	Product	Mode of Action
Aquatic Dye Product		
Acid blue 9, Acid yellow 23	Aquashade	Physical shading of weeds inhibits photosynthesis
Copper Products		
Elemental copper	Clearigate	Photosynthesis inhibitor
Elemental copper	Cutrine-Plus	Photosynthesis inhibitor
Elemental copper	Komeen Aquatic Herbicide	Photosynthesis inhibitor
Copper carbonate	Nautique Aquatic Herbicide	Photosynthesis inhibitor
Diquat Product		
Diquat dibromide	Reward Landscape and Aquatic Herbicide	Cell membrane disruptor
Endothall Products		
Dipotassium salt of endothall	Aquathol K Aquatic Herbicide	Photosynthesis inhibitor
Dipotassium salt of endothall	Aquathol Super K GranularAquatic Herbicide	Photosynthesis inhibitor
Amine salt of endothall	Hydrothol 191, Granular Aquatic Algicide and Herbicide	Photosynthesis inhibitor
Amine salt of endothall	Hydrothol 191, Aquatic Algicide and Herbicide	Photosynthesis inhibitor
Fluridone Products		
fluridone	Avast! Aquatic Herbicide	Photosynthesis inhibitor
fluridone	Avast! SRP Aquatic Herbicide	Photosynthesis inhibitor
fluridone	Sonar A.S.	Photosynthesis inhibitor
fluridone	Sonar PR Precision Release	Photosynthesis inhibitor
fluridone	Sonar SRP	Photosynthesis inhibitor
Pelargonic Acid Product		
Pelargonic acid	Scythe	Cell membrane disruptor
Triclopyr Products		
Triethylamine salt of triclopyr	Garlon 3A	Auxin growth regulator
Butoxethyl ester of triclopyr	Garlon 4	Auxin growth regulator
Triethylamine salt of triclopyr	Renovate 3	Auxin growth regulator

Table 2 Continued

Active Ingredient	Product	Mode of Action
Glyphosate Products		
Isopropylamine salt of glyphosate	Accord Concentrate	Amino acid synthesis inhibitor
Isopropylamine salt of glyphosate	Aquamaster	Amino acid synthesis inhibitor
Isopropylamine salt of glyphosate	Aquaneat	Amino acid synthesis inhibitor
Isopropylamine salt of glyphosate	Eagre Aquatic Herbicide	Amino acid synthesis inhibitor
Isopropylamine salt of glyphosate	Glyphosate VMF Herbicide	Amino acid synthesis inhibitor
Isopropylamine salt of glyphosate	Glypro	Amino acid synthesis inhibitor
Isopropylamine salt of glyphosate	Rodeo	Amino acid synthesis inhibitor
2,4-D Products		
Butoxethylester of 2,4-D	Navigate	Auxin growth regulator
Dimethylamine salt of 2,4-D	Savage Dry Soluble Herbicide	Auxin growth regulator
Dimethylamine salt of 2,4-D	Solution Water Soluble	Auxin growth regulator
Dimethylamine salt of 2,4-D	Weedar 64	Auxin growth regulator

*Derived from Tu, *et al* 2001, Ross and Childs 1996, and product labels

TARGET WEED SPECIES – Which noxious weeds do these herbicides kill and how specific are the herbicides?

Anyone reading this document is no doubt aware that the State of Colorado maintains a list of noxious weeds that must be managed if they occur on state lands. See a Summary Regarding the Colorado Noxious Weed Management Act http://www.ag.state.co.us/DPI/weeds/statutes/noxsum.pdf and/or the Colorado State Noxious Weed List http://www.ag.state.co.us/DPI/weeds/statutes/weedrules.pdf for more information on noxious weeds and noxious weed management law in Colorado.

Table 3 lists the target Colorado noxious weed species for each of the herbicides listed in Tables 1 and 2. **Only those species that are listed by name on a product label are included in Table 3.** A couple of species that are not state listed noxious weeds but are problematic in some State Parks have been included in Table 3.

Table 3. Noxious weeds controlled or suppressed by listed herbicides

Noxious Weed (common name)	Noxious Weed (scientific name)	Herbicides labeled for control of that weed
Black nightshade	*Solanum nigrum*	Glyphosate VMF
Blue mustard	*Chorispora tenella*	Accord, Aquamaster, Eagre, Glyphosate VMF, Glypro, Rodeo
Brome grass	*Bromus spp*	Accord, Aquamaster, Glyphosate VMF, Glypro, Rodeo
Bull thistle	*Cirsium vulgare*	Garlon 4, Savage, Solution, Weedar 64
Canada thistle	*Cirsium arvense*	Accord, Aquamaster, Aquaneat, Eagre, Garlon 3A, Garlon 4, Glyphosate VMF, Glypro, Renovate 3, Rodeo, Savage[P], Solution, Weedar 64[P]
Cocklebur*	*Xanthium strumarium*	Accord, Aquamaster, Aquaneat, Eagre, Glyphosate VMF, Glypro, Rodeo, Savage, Solution, Weedar 64
Common burdock	*Arctium minus*	Garlon 3A, Garlon 4, Renovate 3, Savage, Solution
Common groundsel	*Senecio vulgaris*	Accord, Aquamaster, Eagre, Glyphosate VMF, Glypro, Rodeo
Common mullein	*Verbascum thapsus*	Accord, Aquamaster, Aquaneat, Eagre, Glyphosate VMF, Glypro, Rodeo
Common St Johnswort	*Hypericum perforatum*	Solution
Eurasian water milfoil	*Myriophyllum spicatum*	Aquathol K, Aquathol Super K, Avast!, Avast! SRP, Clearigate, Hydrothol 191, Hydrothol 191 Granular, Komeen, Nautique, Navigate, Renovate 3, Reward, Sonar A.S., Sonar P.R., Sonar S.R.P., Weedar 64
Field bindweed	*Convolvulus arvensis*	Accord, Aquamaster, Eagre, Garlon 3A, Garlon 4, Glyphosate VMF, Glypro, Rodeo, Savage[P], Solution, Weedar 64[P]
Foxtail	*Setaria spp*	Accord, Aquamaster, Rodeo
Hoary cress	*Cardaria draba*	Savage[P], Solution, Weedar 64[P]
Hydrilla	*Hydrilla hydrilla*	Aquathol K, Aquathol Super K, Avast!, Avast! SRP, Clearigate, Cutrine-Plus, Hydrothol 191, Hydrothol 191 Granular, Komeen, Nautique, Reward, Sonar A.S., Sonar P.R., Sonar S.R.P.
Johnsongrass	*Sorghum halepense*	Accord, Aquamaster, Eagre, Glyphosate VMF, Glypro, Rodeo
Jointed goatgrass	*Aegilops cylindrica*	Glyphosate VMF
Knapweed (not specified)	*Centaurea spp*	Accord, Glyphosate VMF, Glypro
Kochia	*Kochia scoparia*	Accord, Aquamaster, Aquaneat, Eagre, Glyphosate VMF, Glypro, Rodeo, Solution
Leafy spurge	*Euphorbia esula*	Glyphosate VMF[P]
Musk thistle	*Carduus nutans*	Aquaneat, Savage[P], Solution, Weedar 64[P]
Orange hawkweed	*Hieracium aurantiacum*	Savage[P], Solution, Weedar 64[P]
Perennial pepperweed	*Lepidium latifolium*	Aquamaster, Eagre, Glyphosate VMF, Rodeo

Table 3 Continued

Noxious Weed (common name)	Noxious Weed (scientific name)	Herbicides labeled for control of that weed
Perennial sowthistle	*Sonchus arvensis*	Savage, Weedar 64
Poison hemlock	*Conium maculatum*	Accord, Aquamaster, Aquaneat, Eagre, Glyphosate VMF, Glypro, Rodeo, Solution
Puncturevine	*Tribulus terrestris*	Aquamaster, Eagre, Glyphosate VMF, Rodeo, Solution
Purple loosestrife	*Lythrum salicaria*	Accord, Aquamaster, Aquaneat, Eagre, Garlon 4, Glyphosate VMF, Glypro, Renovate 3, Rodeo
Quackgrass	*Elytrigia repens*	Accord, Aquamaster, Aquaneat, Eagre, Glyphosate VMF, Glypro, Rodeo
Reed canarygrass*	*Phalaris arundinacea*	Accord, Aquamaster, Aquaneat, Avast!, Avast! SRP, Eagre, Glyphosate VMF, Glypro, Rodeo, Sonar A.S.[p], Sonar P.R.[p], Sonar S.R.P.[p]
Russian knapweed	*Centaurea repens*	Aquamaster, Eagre, Glypro, Rodeo
Russian olive	*Elaeagnus angustifolia*	Accord, Aquamaster, Aquaneat, Glyphosate VMF, Glypro, Rodeo
Russian thistle	*Salsola spp*	Accord, Aquamaster, Aquaneat, Eagre, Glyphosate VMF, Glypro, Rodeo, Savage[p], Solution, Weedar 64[p]
Salt cedar	*Tamarix spp*	Accord[p], Aquamaster[p], Aquaneat[p], Eagre[p], Garlon 4[p], Glyphosate VMF[p], Glypro[p], Rodeo[p]
Sericea lespedeza	*Lespedeza cuneata*	Accord, Aquamaster, Eagre, Garlon 3A, Garlon 4, Glyphosate VMF, Glypro, Rodeo
Shepherd's purse	*Capsella bursa-pastoris*	Accord, Aquamaster, Aquaneat, Eagre, Glyphosate VMF, Glypro, Rodeo, Solution
Toadflax	*Linaria spp*	Solution
Velvetleaf	*Abutilon theophrasti*	Accord, Aquamaster, Aquaneat, Eagre, Glyphosate VMF, Glypro, Rodeo, Solution
Wild oats	*Avena fatua*	Accord, Aquamaster, Eagre, Glyphosate VMF, Glypro, Rodeo
Yellow nutsedge	*Cyperus esculentus*	Accord, Aquamaster, Aquaneat, Eagre, Glyphosate VMF, Glypro, Rodeo
Yellow starthistle	*Centaurea solstitialis*	Aquamaster, Aquaneat, Eagre, Glyphosate VMF, Glypro, Rodeo
Small seedling weeds		Scythe
Seedling annual weeds		Reward

*not state listed noxious weed

[p]partial control or requires repeated applications

Herbicide selectivity

Herbicides may be placed into two general categories: selective and nonselective. Selective herbicides are intended to control weeds without damaging nearby desirable plants, crops, lawns, and ornamentals. Nonselective herbicides are chemicals that kill all plants that are sprayed at an adequate rate. Herbicides in this latter category are often used where no plant growth is wanted such as fencerows, ditchbanks, driveways, etc. Factors that influence selectivity include application rate, time and method of application, environmental conditions, stage of plant growth, and the biological characteristics of the plant (Thayer, et al, 2001). Under certain conditions, selectivity may be less than anticipated, and the risk of non-target plant damage may be quite high. One 2,4-D product label states: "If you are not prepared to accept some degree of crop injury, do not use this product".

Application can be made selective simply by carefully placing the herbicide on target plants and avoiding non-target plants.

In addition, selectivity can be affected by the amount of herbicide applied. For example, fluridone-containing products are relatively non-selective when used at higher concentrations, but they are more selective for Eurasian watermilfoil at low concentrations.

Before choosing to use an herbicide, it's critical to properly identify the plant species in the proposed treatment area, both the target and non-target plants, in order to select the most appropriate chemical and dosage.

Table 4. Herbicide selectivity under ideal conditions*

Chemical	Herbicide Selectivity	Label Warning
Aquatic dye	Non-selective.	Shoreline non-target plants may suffer contact burn if accidentally poured on them
Copper	Non-selective.	Drift to desirable plants may cause injury to non-target plant
Diquat	Generally non-selective.	Avoid spray drift to crops, ornamentals, and other desirable plants as injury may result.
Glyphosate	Non-selective.	Avoid contact of herbicide with foliage, green stems, exposed non-woody roots, or fruit of crops or desirable plants and trees because severe injury or destruction may occur.
Endothall	Generally non-selective.	Avoid contact with or drift to other crops or plants as injury may result.
Fluridone	Can be used for selective or non-selective control of submersed, floating, and emergent aquatic plants.	Follow use directions carefully so as to minimize adverse effects on non-target organisms
Pelargonic acid	Non-selective contact herbicide. Kills actively growing plants.	Care must be exercised to avoid contact of spray with foliage of desirable turfgrass, trees, shrubs, or other desirable vegetation since damage may result.
Triclopyr	Fairly selective. Woody and broadleaf plants	Avoid injurious spray drift. Very small quantities of spray that may not be visible may seriously injure susceptible plants.
2,4-D	Selective. Controls only broadleaf plants.	Drift or runoff may adversely affect non-target plants

*Broadleaf plants are those herbaceous plants (those that die back every year) that are not grasses or sedges.

RELATIVE EFFICACY – How effective is one herbicide product compared to another?

This is not an easy question to answer. Herbicide performance is affected by water depth, water temperature, weather, soil type, herbicide application rate, extent of weed infestation, and other factors. Studies have been done comparing effectiveness of herbicides, but those results demonstrate the effectiveness of the products only under a very specific set of conditions.

It may be necessary to try a product to determine if it provides satisfactory control in your situation.

WATER USE RESTRICTIONS – How is water use restricted following application of these herbicides?

After using aquatic/wetland herbicides, certain restrictions may apply to the use of water for a specific amount of time following the application. Restrictions may include waiting periods before using the water for irrigation, waiting periods before fishing, waiting before swimming or using the water for domestic purposes.

Table 5. Water use restrictions following herbicide application

Active Ingredient	Product	Water Use Restrictions
Aquatic Dye Product		
Acid blue 9, Acid yellow 23	Aquashade	May be used for swimming AFTER COMPLETE DISPERSAL
Copper Products		
Copper	Clearigate	None indicated on label
Copper	Cutrine-Plus	None. Waters treated with Cutrine-Plus may be used for swimming, fishing, drinking, livestock watering, or irrigating turf or ornamental plants immediately after treatment.
Copper	Komeen Aquatic	Areas treated with Komeen may be used for swimming, fishing, drinking, and livestock watering immediately after treatment. However, if treated water is a source of potable water, residue of copper must not exceed 1 ppm.
Copper	Nautique Aquatic	No restrictions on water use. Waters treated with Nautique may be used for swimming, fishing, drinking, livestock watering, or irrigating turf or ornamental plants immediately after treatment
Diquat Product		
Diquat dibromide	Reward	No fishing and swimming restrictions. Restrictions apply to use of water for drinking, livestock consumption, and irrigation. **See label**.
Endothall Products		
Dipotassium salt of endothall	Aquathol K	Do not use fish from treated areas for food for 3 days following treatment. Restrictions apply to use of water for watering livestock, using water for irrigation or for using water for domestic purposes for various periods of time following application depending on concentration used. **See label**.
Dipotassium salt of endothall	Aquathol Super K	Do not use fish from treated areas for food for 3 days following treatment. Do not use water from treated areas for irrigation, agricultural sprays on food crops, or for domestic purposes within 7 days of treatment.
Amine salt of endothall	Hydrothol 191	Do not use fish from treated areas for food for 3 days following treatment. Restrictions apply to use of water for watering livestock, using water for irrigation or for using water for domestic purposes for various periods of time following application depending on concentration used. **See label**.

Table 5 Continued

Active Ingredient	Product	Water Use Restrictions
Amine salt of endothall	Hydrothol 191 Granular	Do not use fish from treated areas for food for 3 days following treatment. Restrictions apply to use of water for watering livestock, using water for irrigation or for using water for domestic purposes for various periods of time following application depending on concentration used. **See label**.
Fluridone Products		
fluridone	Avast!	Irrigation restrictions apply**. See label**
fluridone	Avast! SRP	Irrigation restrictions apply**. See label**
fluridone	Sonar A.S.	Do not use treated water for irrigating greenhouse or nursery plants. Other irrigation restrictions apply. No fishing or swimming restrictions**. See label**
fluridone	Sonar PR	Do not use treated water for irrigating greenhouse or nursery plants. Other irrigation restrictions apply. No fishing or swimming restrictions. **See label**
fluridone	Sonar SRP	Do not use treated water for irrigating greenhouse or nursery plants. Other irrigation restrictions apply. No fishing or swimming restrictions. **See label**
Pelargonic Acid Product		
Pelargonic acid	Scythe	Application must be made 72 hours prior to re-flooding dry aquatic site.
Triclopyr Products		
Triethylamine salt of triclopyr	Garlon 3A	Grazing and haying restrictions. Slaughter restrictions. **See label**
Butoxethyl ester of triclopyr	Garlon 4	Grazing and haying restrictions. Slaughter restrictions. **See label**
Triethylamine salt of triclopyr	Renovate 3	Do not use treated water for irrigation for 120 days. Grazing, haying and slaughter restrictions apply. **See label.**
Glyphosate Products		
Isopropylamine salt of glyphosate	Accord	No restriction on use of treated water for irrigation, recreation, or domestic purposes. For treatment after draw down of water, allow 7 days before reintroduction of water for maximum weed control
Isopropylamine salt of glyphosate	Aquamaster	No restriction on use of treated water for irrigation, recreation, or domestic purposes. For treatment after draw down of water, allow 7 days before reintroduction of water for maximum weed control
Isopropylamine salt of glyphosate	Aquaneat	No restriction on use of treated water for irrigation, recreation, or domestic purposes. For treatment after draw down of water, allow 7 days before reintroduction of water for maximum weed control
Isopropylamine salt of glyphosate	Eagre Aquatic	No restriction on use of treated water for irrigation, recreation, or domestic purposes. For treatment after draw down of water, allow 7 days before reintroduction of water for maximum weed control

Table 5 Continued

Active Ingredient	Product	Water Use Restrictions
Isopropylamine salt of glyphosate	Glyphosate VMF	No restriction on use of treated water for irrigation, recreation, or domestic purposes. For treatment after draw down of water, allow 7 days before reintroduction of water for maximum weed control.
Isopropylamine salt of glyphosate	Glypro	No restriction on use of treated water for irrigation, recreation, or domestic purposes. For treatment after draw down of water, allow 7 days before reintroduction of water for maximum weed control.
Isopropylamine salt of glyphosate	Rodeo	No restriction on use of treated water for irrigation, recreation, or domestic purposes. For treatment after draw down of water, allow 7 days before reintroduction of water for maximum weed control.
2,4-D Products		
Butoxethylester of 2,4-D	Navigate	Unless approved assay indicates 2,4-D concentration is 70 ppb or less, do not use water from treated areas for potable water. See label for other irrigation restrictions that apply.
Dimethylamine salt of 2,4-D	Savage Dry Soluble	Wait 3 weeks to use treated water for irrigation. Delay use of treated water for domestic purposes for 3 weeks following application. Do not allow dairy animals to graze treated areas for at least 7 days.
Dimethylamine salt of 2,4-D	Solution Water Soluble	Wait 3 weeks to use treated water for irrigation. Delay use of treated water for domestic purposes for 3 weeks following application. Do not allow dairy animals to graze treated areas for at least 7 days
Dimethylamine salt of 2,4-D	Weedar 64	Delay use of treated water for irrigation for 3 weeks. Delay use of treated water for domestic purposes for 3 weeks.

TOXICITY – What are some of the known toxic effects of these herbicides?

Every herbicide label comes printed with a signal word from the EPA. This signal word indicates the level of acute human toxicity of the product. Acute toxicity refers to the immediate effects (0-7 days) of a chemical and so is particularly relevant to the herbicide applicator. In Table 6, toxicity data for each herbicide is provided. Acute human toxicity is presented in the form of EPA signal words, caution, warning, and danger. "Caution" signifies low toxicity, "Warning" signifies moderate toxicity and "Danger" indicates a highly acutely toxic substance.

Some chemicals may not be highly acutely toxic, but they may cause some toxicity following long-term exposure. Cancer is an example of a long-term toxic effect. Some pesticides have been evaluated for their ability to cause cancer by agencies such as the U.S. EPA, International Agency for Research on Cancer (IARC), and National Institutes of Health (NIH). These agencies use a weight-of-the-evidence approach, where a panel of scientists evaluates the available data for a particular chemical. The human cancer risk data provided in Table 6 is based on "weight of the evidence". Where general consensus seems to be that the substance is "not likely" a carcinogen, it is stated in Table 6. Where there is suspicion that the chemical may be carcinogenic, the agency that has made that determination is cited.

Another longer-term effect that is of great concern is the ability of a chemical to act as an "endocrine disruptor" or hormone disruptor. The endocrine system -- also referred to as the hormone system -- is made up of glands located throughout the body, hormones which are synthesized and secreted by the glands into the bloodstream, and receptors in the various target organs and tissues that recognize and respond to the hormones. The function of the system is to regulate a wide range of biological processes, including control of blood sugar, growth and function of reproductive systems, regulation of metabolism, brain and nervous system development, and development of an organism from conception through adulthood and old age (U.S. EPA).

A variety of chemicals are known to disrupt the endocrine systems of animals in laboratory studies, and compelling evidence has accumulated that endocrine systems of certain fish and wildlife have been affected by chemical contaminants, resulting in developmental abnormalities and reproductive impairment. Wildlife has been reported with malformed genitalia, aberrant mating behavior, sterility, and other behavioral and physical anomalies (U.S. EPA 2000). Because of the potentially serious consequences of human exposure to endocrine disrupting chemicals, Congress included specific language on endocrine disruption in the Food Quality Protection Act and amended Safe Drinking Water Act in 1996. Following enactment of the Food Quality Protection Act, the EPA began a program of screening chemicals for endocrine disruption potential. The process is ongoing, and with approximately 87,000 chemicals to investigate, will take some time.

The Illinois EPA, the Danish EPA, the European Union, as well as several authors of books on endocrine disrupting chemicals in the environment, maintain lists of chemicals believed to be endocrine disruptors. Of the chemicals under discussion, only 2,4-D shows up on multiple lists and is therefore shown as a "suspected" endocrine disruptor.

Table 6. Herbicide toxicity

Product	EPA Signal Word (Human Acute Toxcity)	Human Cancer Risk	Endocrine disruptor?	Average Acute Ecotoxicity
Aquatic Dye				
Aquashade	Caution	Not likely	?	Fish: slightly toxic
Copper*				
Clearigate	Danger	Inadequate data-EPA	?	Fish: slightly toxic Crustaceans: not acutely toxic Zooplankton: not acutely toxic (based on data for Cutrine)
Cutrine-Plus	Danger	Inadequate data-EPA	?	Fish: slightly toxic Crustaceans: not acutely toxic Zooplankton: not acutely toxic
Komeen Aquatic	Caution	Inadequate data-EPA	?	Fish: slightly toxic Crustaceans: not acutely toxic Zooplankton: not acutely toxic (based on data for Cutrine)
Nautique Aquatic	Danger	Inadequate data-EPA	?	Fish: slightly toxic Crustaceans: not acutely toxic Zooplankton: not acutely toxic (based on data for Cutrine)
Diquat				
Reward	Warning	Not likely	?	Fish: not acutely toxic Birds: slightly toxic Amphibians: not acutely toxic Crustaceans: slightly toxic Molluscs: moderately toxic Nematodes and flatworms: slightly toxic Zooplankton: slightly toxic Cows highly sensitive
Endothall				
Aquathol K	Danger	Not likely	?	Fish: not acutely toxic Bees: not toxic Insects: highly toxic Crustaceans: low toxicity Zooplankton: not acutely toxic

Table 6. Continued

Product	EPA Signal Word (Human Acute Toxcity)	Human Cancer Risk	Endocrine disruptor?	Average Acute Ecotoxicity
Aquathol Super K	Danger	Not likely	?	Fish: not acutely toxic Bees: not toxic Insects: highly toxic Crustaceans: low toxicity Zooplankton: not acutely toxic
Hydrothol 191	Danger	Not likely	?	Fish: highly toxic Amphibians: moderately toxic Molluscs: moderately toxic Phytoplankton: moderately toxic Zooplankton: moderately toxic
Hydrothol 191 Granular	Danger	Not likely	?	Fish: highly toxic Amphibians: moderately toxic Molluscs: moderately toxic Phytoplankton: moderately toxic Zooplankton: moderately toxic
Fluridone				
Avast!	Caution	Not likely	?	Fish: slightly toxic Crustaceans: slightly toxic Molluscs: moderately toxic Zooplankton: slightly toxic Birds: slightly toxic
Avast! SRP	Caution	Not likely	?	Fish: slightly toxic Crustaceans: slightly toxic Molluscs: moderately toxic Zooplankton: slightly toxic Birds: slightly toxic
Sonar A.S.	Caution	Not likely	?	Fish: slightly toxic Crustaceans: slightly toxic Molluscs: moderately toxic Zooplankton: slightly toxic Birds: slightly toxic
Sonar PR	Caution	Not likely	?	Fish: slightly toxic Crustaceans: slightly toxic Molluscs: moderately toxic Zooplankton: slightly toxic Birds: slightly toxic
Sonar SRP	Caution	Not likely	?	Fish: slightly toxic Crustaceans: slightly toxic Molluscs: moderately toxic Zooplankton: slightly toxic Birds: slightly toxic

Table 6. Continued

Product	EPA Signal Word (Human Acute Toxcity)	Human Cancer Risk	Endocrine disruptor?	Average Acute Ecotoxicity
Pelargonic Acid				
Scythe	Warning	Not likely	?	Fish: not acutely toxic Amphibians: slightly toxic
Triclopyr				
Garlon 3A	Danger	Not likely	?	Fish: not acutely toxic Amphibians: not acutely toxic Crustaceans: not acutely toxic Birds: slight-non-toxic
Garlon 4	Caution	Not likely	?	Fish: moderately toxic Insects: not acutely toxic Zooplankton: moderately toxic Birds: slight-non-toxic
Renovate 3	Danger	Not likely	?	Fish: not acutely toxic Amphibians: not acutely toxic Crustaceans: Not acutely toxic Birds: slight-non-toxic
Glyphosate				
Accord	Caution	Inadequate data-EPA	?	Fish: slightly toxic Birds: slightly toxic Crustaceans: moderately toxic Insects: practically non-toxic Zooplankton: slightly toxic Bees: not toxic
Aquamaster	Caution	Inadequate data-EPA	?	Fish: slightly toxic Birds: slightly toxic Crustaceans: moderately toxic Insects: practically non-toxic Zooplankton: slightly toxic Bees: not toxic
Aquaneat	Caution	Inadequate data-EPA	?	Fish: slightly toxic Birds: slightly toxic Crustaceans: moderately toxic Insects: practically non-toxic Zooplankton: slightly toxic Bees: not toxic
Eagre Aquatic	Caution	Inadequate data-EPA	?	Fish: slightly toxic Birds: slightly toxic Crustaceans: moderately toxic Insects: practically non-toxic Zooplankton: slightly toxic Bees: not toxic

Table 6. Continued

Product	EPA Signal Word (Human Acute Toxcity)	Human Cancer Risk	Endocrine disruptor?	Average Acute Ecotoxicity
Glyphosate VMF	Caution	Inadequate data-EPA	?	Fish: slightly toxic Birds: slightly toxic Crustaceans: moderately toxic Insects: practically non-toxic Zooplankton: slightly toxic Bees: not toxic
Glypro	Caution	Inadequate data-EPA	?	Fish: slightly toxic Birds: slightly toxic Crustaceans: moderately toxic Insects: practically non-toxic Zooplankton: slightly toxic Bees: not toxic
Rodeo	Caution	Inadequate data-EPA	?	Fish: slightly toxic Birds: slightly toxic Crustaceans: moderately toxic Insects: practically non-toxic Zooplankton: slightly toxic Bees: not toxic
2,4-D				
Navigate	Caution	Possible carcinogen-IARC, Ambiguous data-EPA	Suspected	Fish: not acutely toxic Amphibians: slightly toxic Earthworm: not acutely toxic Crustaceans: not acutely toxic Insects: slightly toxic Molluscs: not acutely toxic Zooplankton: not acutely toxic Birds: slight to moderately toxic Bees: moderate doses severely impaired brood production
Savage Dry Soluble	Danger	Possible carcinogen-IARC, Ambiguous data-EPA	Suspected	Fish: not acutely toxic Amphibians: slightly toxic Earthworm: not acutely toxic Crustaceans: not acutely toxic Insects: slightly toxic Molluscs: not acutely toxic Zooplankton: not acutely toxic Birds: slight to moderately toxic Bees: moderate doses severely impaired brood production

Table 6. Continued

Product	EPA Signal Word (Human Acute Toxcity)	Human Cancer Risk	Endocrine disruptor?	Average Acute Ecotoxicity
Solution Water Soluble	Danger	Possible carcinogen-IARC, Ambiguous data-EPA	Suspected	Fish: not acutely toxic Amphibians: slightly toxic Earthworm: not acutely toxic Crustaceans: not acutely toxic Insects: slightly toxic Molluscs: not acutely toxic Zooplankton: not acutely toxic Birds: slight to moderately toxic Bees: moderate doses severely impaired brood production
Weedar 64	Danger	Possible carcinogen-IARC, Ambiguous data-EPA	Suspected	Fish: not acutely toxic Amphibians: slightly toxic Earthworm: not acutely toxic Crustaceans: not acutely toxic Insects: slightly toxic Molluscs: not acutely toxic Zooplankton: not acutely toxic Birds: slight to moderately toxic Bees: moderate doses severely impaired brood production

*Most available ecotoxicity data found for copper products was for the triethanolamine complex form of copper found in Cutrine. Little or data was found for the ethanolamine complex form found in Clearigate, the ethylenediamine complex form found in Komeen, or the copper carbonate form of copper found in Nautique. Therefore, the data given in the ecotoxicity column for Clearigate, Komeen and Nautique are based on toxicity studies done on the active ingredient of Cutrine.

None of the other chemicals appear on lists of suspected or known endocrine disruptors, though, in some cases, there may not yet be sufficient data to make this determination.

The ecotoxicity data provided in Table 6 indicate ONLY acute toxicity. The primary data source for ecological toxicity information in Table 6 is the U.S. Environmental Protection Agency Ecotox Database, which is maintained by the U.S. EPA. This database contains over 170,000 records and is a compilation of individual studies conducted on the toxicity of selected pesticides to a variety of aquatic and terrestrial organisms. These data are drawn from a variety of sources, with peer-reviewed journal articles being the primary source. The Pesticide Action Network (PAN) Pesticide Database provides the EPA data in a consolidated and summarized form, and the average acute toxicity ratings in Table 6 have been derived from PAN Pesticide Database. Additional information comes from the EXTOXNET (Extension Toxicology Network) database. In general there seems to be more extensive data for aquatic ecotoxicity than for terrestrial ecotoxicity of herbicide products.

The ecotoxicity data in Table 6 is described as “average” toxicity because multiple studies often give different and conflicting results. For example, one study may indicate

that a particular chemical is highly toxic to fish, while another study indicates the same chemical is only slightly toxic to fish. In such a case, the value provided in Table 6 would be moderate toxicity for fish because moderate is between slight and high toxicity. Individual study references as well as study results (LC_{50} values) can be obtained by searching either the EPA Ecotox Database or the PAN Pesticides Database. The average acute toxicity ratings were assigned based on LC_{50} values according to the guidelines in M.A. Kamrin, Pesticide Profiles: Toxicity, Environmental Impact, and Fate, Lewis Publishers (Boca Raton, FL, 1997). See table below:

Table 7. Assignment of Average Acute Toxicity Ratings

Toxicity Category	LC_{50} (ppb)
Very highly toxic	<100
Highly toxic	100-1,000
Moderately toxic	1,000-10,000
Slightly toxic	10,000-100,000
Practically non-toxic	>100,000

Limitations of the ecotoxicity data

Ecotoxicity data are not available for many species, and most studies conducted to date focus on acute toxicity. However, a pesticide with low acute toxicity may still pose significant chronic hazards (cancer, reproductive and developmental toxicity, endocrine disruption, genetic effects, etc.) or cause behavioral changes that affect species survival. The availability of studies on the chronic toxicity of pesticides to plants and animals is limited. Additionally, there are a number of reasons ecotoxicity hazard ratings can be incomplete or unrepresentative of the true hazard posed by a particular pesticide, including:

- Many species have not been tested, or the species that have been tested may not be representative of those that inhabit a particular geographic area.
- Fewer studies have been conducted on newly registered chemicals, resulting in the appearance that they are less hazardous than those that have been on the market for a longer time and have been more thoroughly studied.
- Many studies look only at a parent compound (active ingredient) and not at the exact formulation of active ingredient that is present in a pesticide product. There may be several different salt forms of a parent active ingredient in use, and the toxicity of each salt form may differ, but complete toxicological data may be available for only the parent compound. Sometimes it is not clear if the toxicological data refers to parent compound or to a salt formulation. In addition, some products require the use of a surfactant when used in the field, but the toxicity of the product including the surfactant may not be known.

OXYGEN DEPLETION=FISH KILL

Special Considerations when Controlling Aquatic Weeds with Herbicides

If an entire pond/lake is treated with herbicides at one time, or if dissolved oxygen level is low at the time of application, ***decay of weeds may remove enough oxygen to suffocate fish***. Water containing very heavy vegetation should be treated in sections to prevent suffocation of fish. See individual labels for aquatic herbicides for recommendations on how to reduce fish kill due to oxygen depletion following herbicide treatment.

ENVIRONMENTAL FATE – How long do these herbicides last in the environment?

"Aquatic herbicides disappear from treated water by dilution, adsorption to bottom sediments, volatilization, absorption by plants and animals or by dissipation. Dissipation refers to the breaking down of an herbicide into simpler chemical compounds. Herbicides can dissipate by photolysis (broken down by light), microbial degradation, or metabolism by plants and animals. Both dissipation and disappearance are important considerations to the fate of herbicides in the environment because even if dissipation is slow, disappearance due to processes such as adsorption to bottom sediments makes a herbicide biologically unavailable" (Langeland, 1998).

Aquatic Dye:

Coloration is gradually lost by dilution, photodegradation and some biodegredation over time. Normal "half-life" of the product is four weeks (Applied Biochemists fact sheet).

Copper:

As an element, copper can persist indefinitely. However, it will bind to water particulates and sediment (EXTOXNET). Copper can be slowly transported out of bottom sediments after plants take it up and moved out of the system through the food chain (Langeland, 1998). Its use in aquatic herbicide formulations has been banned in the state of Washington because of concern about accumulation of the metal in water and sediments. Copper based herbicides are still used in most other states.

Diquat:

Diquat dibromide is highly persistent, with reported field half-lives of greater than 1000 day (EXTOXNET). Although it is water soluble (EXTOXNET), 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). 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 (EXTOXNET). When diquat dibromide is applied to

open water, it disappears rapidly because it binds to suspended particles in the water (EXTOXNET).

Endothall:

Endothall is highly mobile in soil, however rapid degradation limits the extent of leaching. Endothall disappears from soil in 7-21 days (EXTOXNET). It 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 (EXTOXNET).

Fluridone:

Dissipation of fluridone from water occurs mainly by photodegradation (Langeland 1998). Microbial breakdown is probably the most important method of breakdown in bottom sediments (Langeland 1998). The rate of breakdown of fluridone is variable and may be related to time of application. Applications made in the fall or winter when the sun's rays are less direct and days are shorter result in longer half-lives. Fluridone usually disappears from pondwater after about 3 months but can remain up to 9 months. It may remain in bottom sediment between 4 months and 1 year (Langeland 1998).

Pelargonic Acid:

The degradation of pelargonic acid applied to soil occurs very rapidly by microbial means, not through hydrolysis or photolysis (U.S. EPA 1997).

Triclopyr:

In soil and in aquatic environments, the ester and amine salt formulations rapidly convert to the acid, which in turn is neutralized to a relatively nontoxic salt. It is effectively degraded by soil microorganisms and has a moderate persistence in soil environments (EXTOXNET). The half-life in soil ranges from 30 to 90 days, depending on soil type and environmental conditions, with an average of about 46 days. Triclopyr is not strongly adsorbed to soil particles and has the potential to be mobile.

Glyphosate:

Glyphosate is moderately persistent in soil, with an estimated average half-life of 47 days (EXTOXNET). It is strongly adsorbed to most soils, even those with lower organic and clay content (EXTOXNET). 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 (EXTOXNET).

2,4-D:

2,4-D has low soil persistence. The half-life in soil is less than 7 days (EXTOXNET). Dissipation of 2,4-D occurs primarily by microbial degradation (Langeland 1998). 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 (EXTOXNET). 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. (EXTOXNET)

GROUNDWATER – Which pesticides are contaminating groundwater?

What is groundwater?

Groundwater is water found underground in cracks and spaces in soil, sand and rocks. The area where water fills these spaces is called the saturated zone. The top of this zone is called the water table. The layers of soil, sand and rocks in which groundwater is stored are called aquifers. Under natural conditions, ground water moves "downhill" until it reaches the land surface at a spring or through a seep in the side or bottom of a riverbed, lake, wetland, or other surface water body. Ground water can also leave the aquifer via the pumping of a well. The process of ground water outflow into a surface water body or leaving the aquifer through pumping is called *discharge*.

Groundwater supplies are replenished, or *recharged*, by rain and snowmelt. In areas where material above the aquifer is permeable, pollutants can enter the groundwater. Groundwater can be polluted by landfills, septic tanks, leaky underground gas tanks, and from overuse or improper use of fertilizers and pesticides (U.S. EPA).

Groundwater is used for drinking water by more than 50% of the people in the United States. If it becomes contaminated, it will no longer be safe to drink. Additionally, because of discharge, contaminants in ground water can flow into surface water bodies (U.S. EPA and The Groundwater Foundation).

Groundwater contamination potential in Table 8 is based on a list maintained by the California Department of Pesticide Regulation (DPR). A number of pesticides, primarily herbicides and soil fumigants have been found repeatedly in California groundwater. These compounds are labeled as *known* groundwater contaminants (PAN Pesticide Database). Another group of pesticides, labeled as *potential* groundwater contaminants by DPR, have the potential to move into groundwater based on their water solubility, ability to bind to soils, and environmental persistence (PAN Pesticide Database).

National Primary Drinking Water Regulations (NPDWRs) are legally enforceable standards that apply to public water systems. Primary standards protect public health by limiting the levels of contaminants in finished (at the tap) drinking water. Table 8 lists the groundwater contamination potential of herbicides described in this document and if the chemical is regulated under the NPDWR (U.S. EPA).

Table 8. Groundwater contamination potential of listed herbicides

Chemical	Groundwater contaminant*	NPDWRs apply?
Aquatic Dye	Not listed	No
Copper	Not listed	Yes
Diquat	Potential	Yes
Endothall	Potential (dipotassium salt)	Yes
Fluridone	Not listed	No
Pelargonic acid	Not listed	No
Triclopyr	Potential	No
Glyphosate	Potential	Yes
2,4-D	Potential	Yes

*Appears on California DPR list

Potential threats to groundwater

Some pesticides (and not just herbicides) other than those labeled for use in aquatic and wetland sites have been showing up in groundwater around the country. The product labels for many of these products have been marked with groundwater advisories, indicating that the chemical properties of the product are such that there is an elevated risk of groundwater contamination.

Some of these pesticides are agricultural use products. **Atrazine**, for example, is one of the two most widely used herbicides in the U.S. ***It is also the most commonly detected pesticide in ground and surface water*** (EPA 2002). The EPA released a revised risk assessment for atrazine in 2002 which stated that "there is direct evidence that atrazine is associated with endocrine disruption".

Atrazine is not likely to be used in a Colorado State Park, but other herbicides that *are* used in State Parks for noxious weed control do have the potential to contaminate ground or surface water and should be used with caution and awareness.

Picloram (Tordon, Grazon), a restricted use pesticide, is labeled with a groundwater advisory and must not be allowed to contaminate water used for drinking, irrigation, or other domestic purposes. The label states that *use of this chemical where soils are permeable, particularly where the water table is shallow, may result in groundwater contamination*. Its use is prohibited in the San Luis Valley.

Clopyralid (Transline, Stinger, Curtail, Confront) is not nearly as commonly used as atrazine—about 0.1% of the amount used of atrazine, but it is showing up in river basins. Considered by EPA to be "very mobile" in soil and very soluble in water and it "has the potential to leach to groundwater and contaminate surface water." (U.S. EPA, 1997). The label states that "users are advised not to apply clopyralid where soils have a rapid to very rapid permeability throughout the profile (such as loamy sand to sand) and the water table of an underlying aquifer is shallow, or to soils that would allow direct introduction into an aquifer.

Dicamba (Banvel, Clarity) has been found in groundwater and surface water (EXTOXNET) and has a groundwater advisory on it label. The label states that

groundwater contamination may occur in areas where soils are permeable or coarse and groundwater is near the surface.

Some product labels containing the active ingredient **Imazaypyr** contain groundwater advisories. Each label must be read very carefully to determine if the product being used in one of those. Even for products that do not possess a groundwater advisory, keep in mind that ANY imazapyr-containing product must not be used in areas where surface water is present or to intertidal areas below the mean high water mark.

Terrestrial herbicides that may legally be applied to drawdown areas

Use the following products in drawdown zones with care.

Imazapic (Plateau) may be applied to non-irrigation ditches and low lying areas when water has drained, but may be isolated in pockets due to uneven/unlevel conditions. Do not apply if rainfall is forecast in next 48 hours. This product may contaminate groundwater, especially where soils are permeable and water table is shallow.

Metsulfuron methyl (Escort XP). It is legally permissible to apply Escort XP to floodplains where surface water is not present, terrestrial areas of deltas, and low lying areas where water is drained but may be isolated in pockets due to uneven conditions. However, this product appears on the State of California's list of potential groundwater contaminating herbicides.

Consider using Scythe as an alternative to these herbicides in drawdown zones to minimize the potential for groundwater contamination. The active ingredient of Scythe is pelargonic acid, a naturally occurring fatty acid found in the environment and in our food supply (U.S. EPA, 1997). See previous tables for more information on pelargonic acid.

BOTTOM LINE:

The herbicide label contains a great deal of information about the product and should be read thoroughly and carefully before each use. Before applying an herbicide, read the label to determine the following:

- ✓ Is the product labeled for the site where I intend to use it (i.e., ditch bank, canal bank, wetland, pond, lake, river, potable water reservoir, etc)?
- ✓ Is the product labeled for treatment of the weed I wish to control?
- ✓ Can the herbicide be used safely under the particular application conditions found at the proposed site?
- ✓ When should the herbicide be applied (time of year, stage of plant growth, etc.)?
- ✓ What is the appropriate concentration of herbicide that should be applied for my situation?
- ✓ What restrictions apply to watering livestock, fishing, swimming, consuming potable water and irrigation following herbicide application?
- ✓ What is the toxicity to fish and non-target vegetation? Am I willing to accept the possible loss of fish and/or desirable vegetation that may result from this herbicide application?
- ✓ Is the herbicide classified restricted use?
- ✓ What is the signal word? (DANGER, WARNING, CAUTION)
- ✓ What safety equipment should be worn?
- ✓ **DO I NEED TO USE THE HERBICIDE IN THE FIRST PLACE? CAN I CONTROL THE WEED ANOTHER WAY?**

ALTERNATIVES TO HERBICIDES – What other methods exist for controlling weeds in aquatic and wetland situations?

In every case, using herbicides for weed control is a choice. Herbicides are just one tool that may be used for weed management purposes. ***The following section on weed control alternatives is adapted (almost in its entirety) from Creating an Integrated Weed Management Plan, a joint publication of the Colorado Natural Areas Program and The Division of Plant Industry of the Colorado Dept of Agriculture***. A discussion of alternatives specific for aquatic weed control follows.

Pulling

Pulling refers to using your hands or simple implements to uproot plants.

Pulling works best for …

- Small infestations of weeds that can be pulled one patch at a time.
- Annual and biennial plants (although seed banks will remain for some time).
- Shallow-rooted plant species that do not resprout from any residual roots.
- Plants growing on sandy or gravelly soils. If possible, concentrate pulling when the soil is moist and soft; for example, after a heavy, soaking rain.
- Situations where chemicals, motorized equipment or livestock cannot be used or are undesirable.
- Eliminating or reducing seed production in small infestations.

Pulling has limitations such as …

- Pulling generally does not remove the entire weed root system except under the most favorable circumstances. Thus, pulling is often ineffective for killing rhizomatous weed species such as Canada thistle, field bindweed, Russian knapweed, leafy spurge, or yellow toadflax. However, if your goal is reducing seed production, pulling may be very effective. ***If pulled weeds contain seeds, they should be removed from the site and burned or disposed of in a landfill. Don't compost this material!***
- Pulling will not reduce a soil seed bank, although it can keep a seed bank in the soil from increasing.
- It is not cost effective for large infestations, due to the labor involved. Pulling may not be cost-effective for small infestations, either, unless plants are easy to pull and a volunteer work force is available.

These weed species are good candidates for pulling:

Blue mustard
Common mullein
Dalmatian toadflax
Flixweed
Green foxtail
Yellow foxtail
Jointed goatgrass
Musk thistle
Oxeye daisy
Puncture vine
Russian thistle
Plumeless thistle
Scotch thistle
Bull thistle
Myrtle spurge

Pitfalls of pulling include …

- Volunteer burnout from endless hours of boring work.
- Lack of psychological reward if the results of pulling are not apparent.

- Soil disturbance, which stimulates germination of weed seeds in soil, as has been noted with diffuse knapweed.
- Temporarily creating bare soil and providing more sites for weed seed germination and establishment.
- Some weeds produce chemicals that can cause allergic reactions or dermatitis in some people. Always wear work gloves and a long-sleeved shirt for pulling plants. Wash your hands with soap and water afterwards.

Resources for pulling include …

- Volunteers for publicly owned natural areas or those owned or managed by land trusts. Land managers can work with local chapters of service clubs and environmental organizations such as the Lions Club, Rotary, Audubon Society, Colorado Native Plant Society and Sierra Club.
- Crews from the local county jail may be available for a variety of land stewardship tasks on public lands and land trust properties including pulling weeds.
- Persons in the criminal justice system who need to donate time to community service projects may also be available for work on public or land trust lands.
- Tools are commercially available for pulling shrubs and small trees from the ground. The Weed Wrench™ is designed for small trees and shrubs, while the Root Talon is designed for shallow-rooted shrubs and small trees and tap-rooted herbaceous species with thick stalks such as teasel and mullein.
- Local youth may be available for hire at an affordable price during summer vacation.

Cost of pulling …

- Labor is the primary cost associated with pulling. Labor costs vary widely depending on local conditions. A recent study in Montana found that hand pulling alone was effective at reducing flower production of spotted knapweed, but that it was 70 – 500 times more expensive per acre than the other treatments tested.
- Disposal of flowering or post-flowering plants.

Mowing and Cutting

Mowing and cutting employ mechanical or hand tools to sever the aboveground portion of a plant from its roots.

Mowing and cutting work best for …

- Large, relatively flat and dry areas that can be mowed with few safety or equipment concerns.
- Preventing tall, erect biennial weed species such as mullein and teasel from setting seed when other control techniques are not feasible.
- Preventing the "tumbling" action of certain weed species such as diffuse knapweed, kochia and Russian thistle that spreads seeds of these species across wide areas.
- Weakening weed plants by depleting root and rhizome reserves through repeated mowing, in cases where such mowing can be conducted efficiently.
- Combining with other control methods, such as herbicide treatment. Cutting can be extremely effective for killing certain trees and shrubs if it is combined with herbicide treatment of the cut stumps. For example, cutting the stems as close to the ground as possible in the fall and immediately (within 30 seconds) painting the cut stumps with triclopyr herbicide kills tamarisk, Russian olive, Siberian elm, and crack willow.

- Large-scale restorations where weeds need to be controlled during the first growing season or two. In these situations, set the mower blade height relatively high so as to cut the taller weeds but to not cut the shorter, slower-growing desirable species.
- Relatively small areas where adequate labor is available.
- Small infestations of fleshy-stemmed biennial thistles are easy to cut with a sharp machete. These thistles include Scotch, musk, plumeless, and bull thistles.

Mowing and cutting have limitations such as …

- Rarely killing weeds.
- Sites that are inaccessible or too rocky cannot be mowed, although weed whips and machetes can be effective in such situations.
- Having to repeat mowing frequently for control to be effective.
- Cut plants may resprout larger than prior to cutting (tamarisk, Russian olive).
- Weakening some rhizomatous plants only slightly (for example, Russian knapweed) unless the frequency of cutting is very high.

Pitfalls of mowing and cutting include …

- Failing to remove and dispose of cut stems if they contain seeds.
- Dislodging rocks from the mower may be dangerous to the mower operator.
- Turning annual or biennial plants such as diffuse knapweed into short-lived perennials through repeated mowing.
- Weed seeds spread by mowing equipment to areas previously free of infestations. Clean equipment used in weed infested areas before moving it to another area. Make sure that borrowed or rented equipment is free of weed seeds by inspecting equipment before it enters your property. Or, insist that the equipment must be cleaned first.

Resources for mowing and cutting include …

- Ranchers and farmers that have the needed equipment on hand. They may be willing to contract with you to mow or cut weeds.
- Rental stores that have such equipment can be especially useful for suburban landowners.
- Weed whips can be useful for small, isolated or relatively inaccessible areas.
- Chain saws are recommended for trees and large shrubs such as Siberian elm, tamarisk, and Russian olive.
- Double-action loppers are useful for smaller shrubs and tree saplings.

Cost of mowing and cutting …

- Can be relatively low per acre for large areas that can be mowed.
- Can be reduced if you can trade goods or services with a neighbor, especially if the neighbor is motivated by the prospect of reduced weed infestations on his or her property.
- A tractor with a brush hog rotary mower costs about $80 per hour or about $50 - $75 per acre.
- A three-person crew with weed whips costs about $30 per hour.
- Equipment cost for cutting is modest, with a weed whip, a chain saw and a double-action lopper costing about $800 total.
- Labor costs can be a barrier to cutting large areas of weeds such as tamarisk or Russian olive.

Cultural Controls

Cultural controls seek to control weed problems by establishing desired plant species. Cultural techniques manipulate the plant community through cultivating (cutting through and turning over the soil), re-seeding, fertilizing and irrigating.

Cultural controls are most useful for …

- Large restoration projects. Cultivating is often necessary to reduce the number of weed seeds in the soil before planting desirable plant species. Cultivating for a year prior to reseeding kills weeds that have sprouted since the last cultivation and progressively reduces the bank of weed seeds. *Cultivation is not usually appropriate for natural areas because cultivation causes major disruption of established plant communities, and renders them susceptible to weed infestation.*
- Re-establishing native plant communities on disturbed or depleted areas so desirable plants can prevent or reduce weed infestation. *Disturbances such as pipelines, temporary roads, and construction sites need to be re-seeded immediately once the work is completed.* The ***Native Plant Revegetation Guide for Colorado*** (Colorado Natural Areas Program 1998) discusses this subject in great detail and provides practical advice to landowners and land managers. Copies are available from the Colorado Natural Areas Program.

Cultural controls have limitations such as …

- Cultivating is not normally suitable for natural communities.
- Cultivating is appropriate only for restoration of drastically disturbed sites.
- Lack of seeds from locally adapted plants.
- Lack of seeds of certain native species, especially forbs and shrubs.

Pitfalls of cultural controls include …

- Seed mixes may be contaminated with weed seeds.
- Cultivation may result in wholesale germination and establishment of weed species if there is not adequate follow-up weed control.
- Temporary cover crops such as wheat, rye or barley used to reduce soil erosion must be mowed or grazed to eliminate their seed production.
- Promoting weed growth by adding unneeded nitrogen fertilizers. Native plant species are generally adapted to low-nitrogen conditions, while weed species are adapted to high-nitrogen conditions. Only add nitrogen fertilizer if tests show that soil nitrogen levels are insufficient to support native species.
- Common components of commercial seed mixes such as yellow sweetclover, smooth brome, and Kentucky bluegrass are often considered weeds in the context of natural lands and natural areas.
- Importing weed seeds on borrowed or rented equipment. You can reduce this risk by inspecting equipment before it enters your property or you can insist that the equipment must be cleaned first.

Resources for cultural controls include …

- Local farmers and ranchers who probably have all the necessary equipment for hire.
- Seed companies. See the *Native Plant Revegetation Guide for Colorado* for a list of seed companies.

Cost of cultural controls and reseeding …

- A typical cost of contracting out the cultivation of a 10-acre restoration area can range from about $40 - $100/acre, and may include a base fee for mobilizing equipment of something on the order of $1000, assuming the equipment is available for hire locally.
- The cost of reseeding a construction site should be included in the cost of the project.
- The cost of seed is highly variable depending on species and availability. Common native perennial grasses commonly cost between $3 - $10 per pound. The cost of seed alone for reseeding an acre of land could vary from $10 - $50 per acre.
- A low-cost alternative to seeding is to use native (weed free) hay as a mulch and seed source.

Livestock Grazing

Land managers can use cattle, sheep and goats to selectively overgraze certain weed species, thereby weakening them. In cases where desirable native species are not attractive to livestock, grazing may favor these species over weeds.

Livestock are most useful for …

- Weeds that are palatable (at least at some point during the year) and non-toxic to livestock. Weeds vary greatly in their palatability to types of livestock. Generally speaking, the preference for grasses declines from horses to cattle to sheep to goats. Furthermore, goats and sheep are more likely than horses or cattle to relish broadleaf weeds (forbs).
- Leafy spurge control. Goats and sheep are very effective control agents for all but the smallest infestations, especially in riparian areas.
- Low-level, widespread weed infestations where other control techniques are not cost-effective.

Livestock have limitations such as …

- Lack of availability of goats and sheep or even cattle when and where you need them.
- Need for water and fencing or herding to control livestock movement.
- The need to manage the intensity and duration of livestock grazing carefully to avoid overgrazing, and allow desirable species to recover from grazing impacts.
- Areas where predators such as coyotes, mountain lions and black bears may kill grazing animals, especially sheep and goats.
- Using the proper kind of animal to manage the weeds on your property.
- Need for someone with knowledge of animal husbandry to manage the animals.
- Palatability of weeds varying widely throughout the growing season. For example, young shoots of Canada thistle are very palatable to cattle, while old, mature stalks are not. However, palatability of many weeds can be greatly increased by spraying them with a dilute solution of molasses.

Pitfalls of livestock include …

- Expecting livestock to control weeds without close management. Simply turning animals into a pasture and expecting weed problems to vanish would likely be counterproductive.
- Failing to manage the intensity and duration of livestock grazing to prevent the animals from depleting the desirable plant species they are grazing, or creating disturbance which favors the establishment of weeds.

- Spreading weed seeds in fur or in manure when animals are moved from one area to another. Grazing should be done before weeds set seed.
- Toxicity of weeds such as poison hemlock, halogeton, St. Johnswort and Russian knapweed to grazing animals; toxicity can vary greatly by type of animal.

Resources for livestock include …

- Contract grazing operators, typically using sheep and goats, are now entering the market place for the express purpose of controlling weeds.
- Neighbors with livestock are obvious allies in weed control and sources of grazing animals. They may be willing to provide the animals free of charge to you in exchange for a free grazing opportunity.
- There may be a potential profit opportunity where weeds could be turned into dollars in the form of specialized animal products.

Cost of livestock include …

- Infrastructure such as fencing and water, including capital and maintenance. Cost of fencing is highly variable depending on soil conditions, access and the type of fencing. Modern electric fencing is available that is much less expensive than barbed-wire fencing. Electric fence can be erected on a temporary basis while the animals are grazing then removed once grazing is finished. There are many sources of electric fence materials.
- The cost of contracting with a person to supply and manage grazing animals. You can expect to pay from $19 - $38 per acre to rent goats and sheep for the grazing season.
- Cost of creating a holding area to confine animals (for 10-14 days) which have been grazing weedy areas where weed seeds are present.

Biological Control Agents (Insects)

Biological control agents are organisms (usually insects) that are deliberately introduced to an area to control weeds. The aim of biological control is not eradication, but rather to exert enough pressure on a weed to reduce its abundance to acceptable levels.

Biological control agents are most useful for …

- Reducing seed production or weakening plants.
- Large, dense infestations where other control methods are not cost-effective.
- Situations where a reduced but effectively permanent presence of a noxious weed species is acceptable.

These noxious weed species have biological control programs in Colorado:

- Leafy spurge
- Diffuse and spotted knapweed
- Russian thistle
- Puncturevine
- Musk thistle
- Yellow and Dalmatian toadflax
- Bull thistle
- Canada thistle
- Russian knapweed
- Purple loosestrife

Biological control has limitations such as

- Failing to eradicate the target plant species. Do not use biocontrol agents where you seek to eradicate a weed population. Eradication of weeds with biological agents never occurs.
- Use of biological control is effectively an admission that a particular weed species is here to stay and that this is acceptable.
- Feasible for only a handful of weed species due to the high cost of finding, screening and testing potential control organisms. Biological controls have a mixed record with some tremendous successes but also with many failures.

- Rarely successful as the sole means of control of a weed species.
- Lack of effective biological control agents for most noxious weed species.
- Biological control agents being unavailable when you want them.
- Necessity of having a reservoir of host weeds to support biological agents over the long term. Thus, it may be necessary to leave some weeds to support populations of control organisms. This may be unpopular with neighbors or the public.
- Degree of control is variable and will take several years to achieve.

The biology behind biological control

In its native environment, a plant is constantly attacked by a variety of organisms. Herbivory by insects and other invertebrate animals, and infection by fungi, bacteria and viruses reduces the ability of plants to grow and reproduce, which regulates the population size of a species. When plants are transported to a completely new environment, insects and other organisms in the new environment may not be adapted to feed on or otherwise control the plant species. If this is the case, the introduced plant species may be able to expand its population size enough to become a troublesome weed.

One method of controlling weeds involves finding organisms in the plant's native environment that attack the plant and reduce its growth and / or reproduction. After a lengthy period of laboratory and field testing to determine if the organism is likely to attack non-target plants, these organisms may be released to control the weed in its new environment. The federal government approves individual insect species for release as biological control agents. Generally, federal land management agencies are not required to perform additional reviews to release approved biocontol agents. Other organizations may have internal policies that govern the intentional release of biological control agents.

Pitfalls of biological control agents include …

- Insects attacking beneficial, non-target plants. For example, the seed weevil *Rhinocyllus conicus* that has been used to control musk thistle also attacks native thistles. There are indications that this weevil is adversely affecting a rare thistle (*Cirsium ownbeyi*) in Colorado. The weevil *Larinus planus*, introduced for control of Canada thistle, has been reported to attack native thistle species as well (S. Louda, pers. comm.). Insects that have been released to control St. Johnswort also feed on native *Hypericum* species, and some insects released for leafy spurge control also attack native spurge species.
- Inability to establish populations of biological control organisms for reasons relating to climate, soils and so forth that are not well understood.

Resources for biological control agents include …

- The Colorado Department of Agriculture's Insectary in Palisade rears biological control insects and provides them free of charge to Colorado residents. Consult your county weed supervisor to find out if biological control agents have been used successfully in your area or call the Insectary at (970) 464-7916.

Cost of biological control agents …

- Biological control agents are available free of charge from the Insectary. Availability is limited.

- Insects are available for sale from commercial sources, often for several hundred dollars for a sufficient number of insects for one release.

Prescribed Burning

Prescribed burning is planning, setting and managing fires to accomplish resource management objectives.

Prescribed burning is a complicated subject and will not be discussed in great detail here. Consult land managers and scientists who have experience with local conditions if you are contemplating prescribed burning.

Prescribed burning works best when …

- The noxious weed species you want to control is much more susceptible to the effects of burning than are the intermingled desirable plant species.
- Controlling cool-season grasses in prairie restorations.
- A proper monitoring plan is in place to evaluate the effects and success of the project.

Limitations of prescribed burning include …

- The need for intensive planning to insure that the burn will be safe and accomplish the intended resource management objectives.
- Smoke management problems, especially in urban areas, that limit your ability to burn.
- Availability of crew members who have "red cards" that signify a minimal level of fire training.
- Availability of experienced crews to manage the prescribed burn in your particular fuel type(s).

Pitfalls of prescribed burning include …

- The possibility of burns getting out of control and damaging property and endangering human life.
- Liability issues if a fire gets out of control.
- Arid environments cannot tolerate frequent burning.
- Massive germination and establishment of weed seeds following burning. However, this may be advantageous, in that it may assist in the depletion of the bank of weed seeds in the soil, if you are prepared to control the resulting weeds.

Resources for prescribed burning include …

- Colorado State Forest Service. Trained CSFS staff can prepare prescribed burn plans for private landowners for a modest charge.
- In-house fire experts of state and federal land management agencies can advise public land managers about prescribed burning and prepare prescribed burn plans.
- Certain county open space programs have in-house fire experts who may be willing to share their experience with you and to direct you to additional knowledgeable people.
- Private consultants and contractors who specialize in prescribed burning.

Alternatives in Aquatic Weed Control

Methods similar to those described above can be used for controlling aquatic weeds too. See Appendix 1 for information on **hand pulling, cutting, and raking** aquatic weeds. The information in Appendix 1 comes from the Washington State Department of Ecology, Water Quality Website.

Other methods for controlling aquatic weeds

Bottom screening:
Bottom screens will control most aquatic plants. A bottom screen or benthic barrier covers the sediment like a blanket, compressing aquatic plants while reducing or blocking light. It is analogous to using landscape fabric to suppress weeds. Materials such as burlap, plastics, perforated black Mylar, and woven synthetics can all be used as bottom screens. Some people report success using pond liner materials. There is also a commercial bottom screen fabric called Texel, a heavy, felt-like polyester material that is specifically designed for aquatic plant control (Washington State Department of Ecology, Water Quality).

It is very important to anchor the bottom barrier securely to the bottom. Unsecured screens can create navigation hazards and are dangerous to swimmers.

See Appendix 2 for how to construct and install a bottom screen.

Grass carp
The most widely used biological control agent to date is an herbivorous fish, the grass carp (also known as the white amur). The grass carp is native to China and Russia and can live 15-20 years. This fish consumes most filamentous algae and submersed vegetation. ***Since it has the potential to denude a body of water of its vegetation, it must be used with great caution and not in bodies of water where native submerged vegetation is desired***. This biological control method typically utilizes a sterile fish to prevent its reproduction in the wild.

See Appendix 3 for information (from Texas) on using grass carp for aquatic weed control.

I'm currently trying to ascertain from Colorado Division of Wildlife if any restrictions apply to use of this fish in Colorado for aquatic weed control purposes. The person I need to speak with is out of town.

In short, it seems there are restrictions on the Western slope but not the Eastern slope. Will fill in the information after I speak to the one person who seems to have the specific answers.

The WPS was created to protect the health of individuals applying herbicides as well as those working in areas treated with herbicides. Consequently, although most State Parks herbicide applications are not legally subject to WPS requirements, it might be a good idea to behave as if they are.

PESTICIDE USE REGULATIONS – What regulations apply to herbicide use in situations found in Colorado State Parks?

It should go without saying by now that ***the primary source of information for any herbicide is the product label***. The label dictates exactly how, when, and where an herbicide may be applied, and violation of label requirements violates federal law. **No special permits are required for herbicide applications in aquatic or wetland situations in the state of Colorado, including applications made directly to drinking water reservoirs** (Sandra McDonald, personal communication). If the use is allowed on the label, and if the application is made in strict accordance to the requirements on the label, then the label serves as the permit (Sandra McDonald, personal communication).

Other laws may apply to herbicide applications depending on the situation.

EPA Worker Protection Standard

The Worker Protection Standard (WPS) is intended to protect agricultural workers, and applies only to such workers. Special herbicide use requirements intended to protect the health of agricultural workers appear on product labels printed in a box that says "Agricultural Use Requirements". These special requirements may include personal protective equipment (PPE) that must be worn during or after herbicide application, herbicide application sign posting requirements, as well as restricted entry interval (REI) information. The REI indicates the period of time when workers may not re-enter a sprayed area or must wear PPE to do so.

In most cases, the WPS is not applicable to herbicide applications made in Colorado State Parks, so neither would be the special requirements found in the "Agricultural Use Requirements" box (Sandra McDonald, personal communication), though all other label requirements WOULD apply. ***The WPS is applicable, however, in any situation in which an agricultural commodity is produced on state park land***. For example, any leased agricultural land on state parks property is subject to the provisions of the WPS, and the agricultural use requirements would need to be met in such cases. Other examples of situations that are covered by WPS requirements include hay fields maintained on state park land, as well as areas on state park land used for the production of forest products for sale.

When an agricultural use activity subject to WPS requirements exists on state park land, the WPS requirements apply ONLY to the area of the park in which the agricultural

activity occurs and not in other parts of the park used only for recreation purposes (Sandra McDonald, personal communication). Additionally, the WPS applies only to workers working in the agricultural area and not to park visitors or other non-agricultural workers.

If a non-WPS covered herbicide application has been made, and Parks staff must re-enter the treated area, remember that there are health concerns associated with entering a recently sprayed area. The "Agricultural Use Requirements" section of the label may be useful to *all* workers interested in minimizing the health risks associated with herbicide use. By wearing PPE (even if it is not required) and respecting REIs, a worker may reduce his or her chance of a toxic exposure.

In Colorado, public notification of herbicide application is required for turf applications, ornamental applications, and situations subject to the provisions of the WPS (Sandra McDonald, personal communication).

Many park visitors would probably like to decide for themselves if it is acceptable to them to enter a recently sprayed area of the park. Consider making public notification of herbicide applications a priority, even if it is not legally required.

Preble's Meadow Jumping Mouse Habitat

The Preble's meadow jumping mouse is a federally protected species. It is listed as threatened under the provisions of the Endangered Species Act.

Special temporary rules (set to expire in May 2004) were enacted in 2001, allowing for "incidental take" of the PMJM during the course of noxious weed control activities. This means, noxious weed control activities may occur in areas known to be habitat for the PMJM as long as the following conditions are met: 1) weed control is implemented in accordance with the weed management plan adopted by the appropriate county or municipal government 2) weed control is implemented in consultation with the appropriate weed control officer designated by the applicable county or municipal government, 3) weed control activities implement the best available integrated weed management practices as prescribed in the local undesirable weed management plan, and, 4) weed control activities follow herbicide application guidelines as prescribed by herbicide manufacturers and federal law. The special rule may be extended after May 2004, so USFWS should be contacted after that time. Without this rule, anyone engaging in weed control activities that could potentially result in an incidental taking of PMJM would need to seek an authorization from the USFWS (Peter Plage, personal communication).

Despite the special rule, parks on federal land or land with federal nexus may be subject to the biological assessment requirement of Section 7 of the Endangered Species Act. Section 7 requires that a biological assessment be performed if activities are proposed that may result in a take of a listed species. In such a case, the federal agency owner of the land should be consulted (Peter Plage, personal communication).

If it is believed that the PMJM may be present, but its presence is not verified, then either trap for it to confirm its presence or proceed as though it is there (Peter Plage, personal communication).

If any threatened or endangered species other than PMJM occurs (or is believed to occur) on State Parks land, contact the US Fish and Wildlife Service for advice on how to proceed with an herbicide application that could impact these species.

Colorado Pesticide Applicator Act

The Colorado Pesticide Applicator Act requires that State Parks applying restricted use pesticides register as Public Applicators with the state. Contact the Colorado State Department of Agriculture for more information. Registration materials are available online as well:
http://www.ag.state.co.us/DPI/PesticideApplicator/AppGenInfo.html

Colorado State Parks applying general use pesticides ONLY are not required to register as public applicators but are encouraged to register with the state (Sandra McDonald, personal communication). Registration with the state means the applicator agrees to be governed by the rules and regulations of the Pesticide Applicator Act for all pesticide applications, including those involving general use pesticides. Contact the Colorado State Department of Agriculture, Plant Industry Division for more information.

Though it may seem like registration with the state creates an unnecessary burden, the benefits of registering and adhering to all pesticide application guidelines are that State Parks employees, neighbors, and visitors are protected to the greatest degree.

Most of the rules within the Pesticide Applicator Act fall under the heading of common sense. They dictate that pesticides be stored and labeled properly, and pesticide storage areas be clearly marked. The rules also dictate notification of neighbors listed on the pesticide-sensitive registry in the event of any turf or ornamental application, and they require that at least one sign notifying the public of the application be posted for any turfgrass, ornamental application, or *aquatic* pesticide application. If rules change in the future, and strict adherence to pesticide application guidelines becomes a requirement, Colorado State Parks will already be ahead of the game if it has already begun to make all pesticide applications in accordance with the Pesticide Applicator Act.

Remember, if restricted use pesticides are being used, then the park is already subject to the rules and regulations pertaining to the Pesticide Applicators' Act.

See the Rules and Regulations Pertaining to the Administration and Enforcement of the Pesticide Applicators' Act:
http://www.ag.state.co.us/DPI/PesticideApplicator/Publications/applicator.pdf

Resources:

Colorado State Department of Agriculture, Plant Industry Division, Lakewood CO
303-239-4140
http://www.ag.state.co.us/DPI/home.html

Colorado State Department of Agriculture, Plant Industry Division,
Pesticide Registration Query Page,
http://www.ag.state.co.us/DPI/Pesticides/PPRS/PPRSQuery.htm

Colorado State Division of Wildlife, Aquatics Section, Denver CO
303-291-7359
http://wildlife.state.co.us/aquatic/

Colorado Environmental Pesticide Education Program, Colorado State University,
CEPEP Specialist, 970-491-6027
http://www.colostate.edu/Depts/SoilCrop/extension/CEPEP/index.htm

U.S. Environmental Protection Agency, Region 8, Denver CO
Team Leader, Pesticides Program, 303-312-6020
http://epa.gov/region8/toxics_pesticides/pests/pesthome.html

U.S. Environmental Protection Agency, Worker Protection Standard
http://www.epa.gov/pesticides/safety/workers/workers.htm

U.S. Fish and Wildlife Service, Region Six, Lakewood CO
Regional Coordinator, Endangered Species Program, 303 275-2370
http://mountain-prairie.fws.gov/endspp/

U.S. Fish and Wildlife Service, Region Six, Grand Junction CO
Regional Coordinator, Endangered Species Program, 970-243-2778
http://mountain-prairie.fws.gov/endspp/

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Appendix 1

Description of Aquatic Plant Management Methods

Hand-Pulling

Hand-pulling aquatic plants is similar to pulling weeds out of a garden. It involves removing entire plants (leaves, stems, and roots) from the area of concern and disposing of them in an area away from the shoreline. In water less than three feet deep no specialized equipment is required, although a spade, trowel, or long knife may be needed if the sediment is packed or heavy. In deeper water, hand pulling is best accomplished by divers with SCUBA equipment and mesh bags for the collection of plant fragments. Some sites may not be suitable for hand pulling such as areas where deep flocculent sediments may cause a person hand pulling to sink deeply into the sediment.

Cutting

Cutting differs from hand pulling in that plants are cut and the roots are not removed. Cutting is performed by standing on a dock or on shore and throwing a cutting tool into the water. A nonmechanical aquatic weed cutter is commercially available. Two single-sided stainless steel blades (razor sharp) forming a "V" shape are connected to a handle which is tied to a long rope. The cutter can be thrown about 20 - 30 feet into the water. As the cutter is pulled through the water, it cuts a 48-inch wide swath. Cut plants rise to the surface where they can be removed. The stainless steel blades that form the V are extremely sharp and great care must be taken with this implement. It should be stored in a secure area where children do not have access.

A battery-operated cutting tool called a Swordfish is also commercially available. It works similarly to an underwater lawn mower.

*__Case Study from Conesus Lake in New York__: "*One of the Conesus Lake Association members has used a cutting device with good success for the past several years. Swimming and wading areas around the dock are clear of milfoil. The steps are as follows:*

1. *Early spring, when weed growth is first noticed is the best time to start. If early enough in the spring a wet suit or chest waders will be necessary or use this*

method from the dock. Pick a day when the wind will direct floating cut weeds towards your dock or shore. Be respectful of your neighbors. Remember, cut weeds, if left in the lake, will reseed new plants and leave nutrients in the lake.

2. *Hold firmly on the end of the line and throw the cutter Y legs first. Use a back and forth motion as you retrieve the cutter by tugging on the line. Allow the cutter to settle to the bottom between tugs.*
3. *As the cut weeds float to the surface, use two large fish nets to gather them. As one net is full, let the water drain by using the second net.*
4. *The cut weeds can be deposited on a cross hatched, wooden lattice or fencing material so they can drain thoroughly (see also the case study for raking below).*
5. *When drained sufficiently, use a pitchfork to place the semi-dry weeds into plastic bags for use as garden mulch or for disposal. It is impractical to try and burn the weeds since too much time is required for complete drying.*

Based on several year's experience with this weed control method, the results will be acceptable if the process is repeated every other week or two. Over time the regrowth of the weeds becomes less of a challenge".

Raking

A sturdy rake makes a useful tool for removing aquatic plants. Attaching a rope to the rake allows removal of a greater area of weeds. Raking literally tears plants from the sediment, breaking some plants off and removing some roots as well. Specially designed aquatic plant rakes are available. Rakes can be equipped with floats to allow easier plant and fragment collection. The operator should pull towards the shore because a substantial weight of material can be collected in a short distance.

***Case Study from Conesus Lake in New York**: "*One of the Conesus Lake Association members has used a weed rake with great success for the past several years. Swimming and wading areas around the dock are clear of weeds. The process is the same that can applied to the use of any weed rake regardless of design or model. The steps are as follows:*

1. *Early spring, when weed growth is first noticed is the best time to start. If early enough in the spring, a wet suit or chest waders will be necessary. Pick a day when the wind will direct floating weeds toward your dock or the shore. Be respectful of your neighbors. Remember, weeds, if left in the lake, will reseed new plants and leave nutrients in the lake!*
2. *Use a back and forth motion with the rake, much as you would with a vacuum cleaner.*
3. *As the weeds float to the surface, use two large fish nets to gather them. As one net is full, let the water drain by using the second net.*
4. *Once drained, the weeds can be deposited in a large trash container lined with a plastic bag.*

5. *Place an old window screen or a framed screen on top of the trash can and move the can to a place where it can sit for a while. Invert the trash can over a couple of 2 x 2's or some like means to prop up the screened area allowing water to drain out through the screen over time.*
6. *After a few days, the remaining weeds will be light, compacted, and ready for disposal and pickup by garbage collection. Or, if desired, the weeds can be mulched and used in gardens for fertilizer. It is impractical to try to burn the weeds since too much time is required for complete drying.*

Based on several year's experience with this weed control method--- and a process that was repeated every week or two --- this Conesus Lake member has been very pleased with the results. He reported that the growth of weeds slows down over time. This may be due to the back and forth movement of the rake".

Cleanup

These methods create plant fragments. It's important to remove all fragments from the water to prevent them from rerooting or drifting onshore. Plants and fragments can be composted or added directly to a garden.

Advantages

- Manual methods are easy to use around docks and swimming areas.
- The equipment is inexpensive.
- Hand-pulling allows the flexibility to remove undesirable aquatic plants while leaving desirable plants.
- These methods are environmentally safe.

Disadvantages

- As plants regrow or recolonize the cleared area from fragments, the treatment may need to be repeated several times each summer.
- Because these methods are labor intensive, they may not be practical for large areas or for thick weed beds.
- Even with the best containment efforts, it is difficult to collect all plant fragments. Most aquatic plants can regrow from fragments.
- Some plants, like water lilies which have massive rhizomes, are difficult to remove by hand pulling.
- Pulling weeds and raking stirs up the sediment and makes it difficult to see remaining plants.
- Hand-pulling and raking disturbs bottom-dwelling animals.
- The V-shaped cutting tool is extremely sharp and must be only used with great care.

Costs

- Hand-pulling costs up to $130 for the average waterfront lot for a hired commercial puller.
- A commercial weed cutter costs about $130 with accessories.

- A commercial rake costs about $95 to $125. A homemade weed rake costs about $85 (asphalt rake is about $75 and the rope costs 35-75 cents per foot).

Vendors

The following list of vendors is provided for your information. It is not our intention to endorse or promote specific vendors or products and this list may not be comprehensive. Vendors who wish to be added to this list should contact Kathy Hamel at kham461@ecy.wa.gov.

http://www.arrowtooth.com

http://dhdocks.com/shop.cfm

http://www.bartswatersports.com/catalog.asp?C=27

http://www.stoneycreekequip.com/form/weedrake.htm

https://secure.westserver.net/lakedoctors/catalog.htm

Swordfish Vendor: http://www.aquamow.com/products.html

This document comes directly from the Washington State Department of Ecology Water Quality Website

http://www.ecy.wa.gov/programs/wq/plants/management/aqua022.html

Appendix 2

Constructing and Installing Bottom Screens

Many lake-front residents have problems with aquatic plants growing in swimming areas or alongside docks. Bottom screening provides an inexpensive and effective means of controlling these plants. This document provides instructions for building and installing bottom screens

A bottom screen is a cloth-like material that covers the lake bottom like a blanket. Bottom screens block light, preventing the growth of aquatic plants. Bottom screening also called bottom barriers or benthic barriers can be an excellent method of controlling aquatic plants at swimming beaches and in boat mooring areas.

Many aquatic plants can be controlled with bottom screens. Waterlilies are controlled well, although installation and maintenance difficulties can be created by their large roots and the mucky sediments in which they sometimes grow. Freely floating plants such as coontail and bladderwort that do not root in the sediment, can not be controlled by bottom screening.

Bottom screens can be installed by the home owner. The material may be placed directly on the lake bottom or attached to frames to facilitate handling under water. The use of bottom screens is usually confined to shallow water, unless diving gear is available.

Materials Required for Three 12' X 12' Bottom Screen Frames

- Fifteen 2" x 2"s, each twelve feet long. *Note: Fir and cedar* 2" x 2*"s are suitable and may be more readily available, in twelve foot lengths, than pine.*
- Nails (#6 Spiral) or screws, 2" long.
- Marine plywood, 1/4 for making gussets. Forty eight gussets are required for bracing, top and bottom of each of the three 12' X 12' frames. Approximately twelve square feet of plywood is required.
- Lath (if nails instead of staples are used for securing material to the frames). About 165 lineal feet required.
- Screening material, allowing for some selvage, about 440 square feet required.
- Twelve polypropylene bags 2' x 2' for use as sandbags.
- Clean sand or gravel to fill twelve bags approximately 3/4 full, about 1 cubic yard.

- Hammer
- Saw
- Utility knife or heavy scissors for cutting material.
- Staple gun (if staples are used instead of lath for securing material to the frames).

Building Instructions

Screening Materials

Screening materials should be opaque and of a sturdy material that doesn't tear easily. Ideally these materials should be heavier than water and permeable to the gases that will be generated by rotting vegetation. Materials suitable for screening include burlap, woven synthetics, perforated black Mylar, landscaping fabric (sold in hardware stores and at plant nurseries), and geotextiles used in road construction. Keep in mind that some fabrics, such as burlap, will deteriorate more rapidly than others.

Screen Construction

1. Lay out the 2 x 2's for one frame four sides, plus middle brace.
2. Measure and cut gussets from the 1/4 marine plywood. These will be triangular pieces with each side 5" long. Sixteen gussets are required for each frame.
3. Nail or use screws to secure gussets at each corner of the frame and at both ends of the center brace on the "up" or visible side of the frame.
4. Carefully turn the frame over and lay the screening material on top. *Note: Screening material can be used in six foot widths if it is more conveniently available .*
5. Nail gussets or use screws to secure them to one end of the frame with the screening material underneath.
6. From the opposite end of the frame, pull the material tight and nail or screw down gussets.
7. Staple the screening material to each of the 2 x 2's so that it is secured along the entire length (or nail down, using the lath).
8. Trim excess material even with the outside of the frame.
9. Repeat for other frames.

Sand Bags

Sand bags are used to anchor the bottom screens to the sediment. Even the most porous materials will billow due to gas buildup, sometimes causing the frame to "lift off" the bottom. Therefore, it is very important to anchor the bottom screen securely. Unsecured screens can create navigation hazards and are dangerous to swimmers. Anchors must be effective in keeping the material down and must be regularly checked.

1. Fill each bag about 2/3 full with **clean** sand or gravel (fill material containing dirt will cloud the water as the bags are put into place). If the screen site has a soft or muck bottom try filling the bags only 1/2 full. The bags may cause the screens to sink if the sediment is very soft.
2. Tie the bags closed with string.

Placing Bottom Screens

Site Considerations:

Installation is easier in the winter when plants have died back or in early spring before the plants start growing. In summer, it's desirable to cut or hand pull the plants first.

Be aware that boat propellers may dislodge bottom screens in shallow areas. Also fish hooks can get caught in the material. If the screened area is to be used for boat mooring, swimming, fishing, or wading, it may be prudent to post a sign telling users that the bottom screen is in place.

1. Remove any sticks and stones from the area to be screened, especially where the edges of the frame will lie.
2. Slide the frame into the water. This can be more easily done with two people.
3. While the screens are floating on the surface, cut slits about one inch long in the material. This will allow the air trapped under the screen to escape, making it easier to lower the screen to the bottom. The slits will also allow gases generated by rotting vegetation to escape.
4. If you are installing the screen near a dock, line up the frame with the dock. Lower the frame into place by placing a sandbag on each corner and allowing the frame to slowly sink. Once it is on the bottom and in the position you want, add a sandbag to each end of the center brace.
5. Install the second and third frames adjacent to each other. If two people are working together, one can push while the other squeezes the frames together. Make sure there are no gaps between each frame and that the cross pieces are parallel with the other frames.
6. Place the remaining sand bags, concentrating the weight where the frames meet. Overlap the bags so that they rest partly on each frame. This will help to keep the frames in place.
7. Pull the aquatic weeds along the edge of the frames to keep them from growing over the screened area. Milfoil tends to "canopy" over adjacent areas.
8. If any mechanical harvesting is taking place on the lake, notify the equipment operator about the bottom screen and ask him/her not to harvest in this area.

Relocating Screens

Bottom screens installed during the growing season will suppress the plants within about four weeks. The bottom screens can then be moved to a new location or be removed for storage. If bottom screens have been in place during the growing season, plant suppression will usually be effective for the remainder of the summer.

Screens are easily moved underwater by two people. They can be moved around the same dock or to an adjacent dock.

Maintenance

The duration of weed control depends on the rate that weeds can grow through or on top of the bottom screen, the rate that new sediment is deposited on the screen, and the durability and longevity of the material. Regular maintenance can extend the life of most bottom screens

1. Frequently check the bottom screen for gas bubbles. If gas bubbles are forming under the material, cut one or two additional slits on top of the bubble to release the gas.
2. If the screens are not removed from the water at the end of the season, they should be checked at the beginning of the new growing season for any accumulation of sediment. This can be removed by sweeping or upending the screens.

Fish Spawning Areas

Screens covering spawning beds should be moved in the early spring and not replaced until the spawning activity is over, usually sometime during the early summer.

This document comes directly from the Washington State Department of Ecology Water Quality Website

http://www.ecy.wa.gov/programs/wq/plants/management/aqua022.html

Appendix 3

Grass Carp in Texas

by Earl Chilton, PhD

The grass carp (scientific name *Ctenopharyngodon idella*) is one of the largest members of the minnow family (Cyprinidae). The species is native to large Asian rivers in China and the Soviet Union. In their native habitat grass carp typically reach weights of 65-80 pounds, but fish have been reported up to 400 pounds. Fish up to twenty-one years old have been reported, however, most seem to live 6-10 years. Grass carp are easily distinguished from common carp in that they are more slender and have no barbels ("whiskers").

Reproduction

Reproduction in normal grass carp in influenced by temperature, age/size, and water conditions. Fish reach maturity when about 4 years old at weights of 9-11 pounds. Spawning occurs when water temperature rises above 68 degrees Fahrenheit. Because grass carp eggs are slightly heavier than water, current during spawning is required to keep eggs suspended while they wait to hatch. In general, successful spawning takes place under rising water conditions in very long rivers. The number of eggs produced by each female is very high in normal diploid grass carp (fish with two sets of chromosomes in each cell). Females may produce over one million eggs in a season. Triploid grass carp (fish with an extra set of chromosomes in each cell) are functionally sterile.

Feeding & Vegetation Control

Grass carp fry begin feeding on microscopic animals, but by the time they reach about 3 inches in length they are virtually 100% vegetarian. Feeding is strongly affected by temperature. Active feeding begins at 45-46 degrees Fahrenheit. Whereas triploids feed at nearly the same rate as diploids, hybrids (a cross between grass carp and a bighead carp) feed at substantially lower rates. Therefore, vegetation control is most efficiently achieved with diploid or triploid grass carp. These fish may consume more than their own weight in plant species. Hydrilla and similar species are almost always most preferred, and control or elimination is usually assured if proper stocking densities are used. Vegetation control has been reported with stocking densities as low as two or three grass carp per vegetated acre.

Grass carp do not seem to impact native (North American) fish species directly, through predation or competition. However, their influence may be strongly felt in that vegetation removal can affect a wide variety of species by destroying feeding and nursery habitat. As a result, grass carp should not be stocked in areas where declines in plant-associated fish species is of concern.

Movement

Results of research with triploid grass carp indicate that soon after stocking, fish become associated with aquatic vegetation. Subsequent movement of fish is a function of size

and age. Older, larger fish tend to move more than young grass carp. As a result, fish should be used to prevent escape.

Distribution

Grass carp were first introduced into the United States in 1963 by the U.S. Fish and Wildlife Service, and were used in experiments at the Fish Farming Experimental Station, Stuttgart, Arkansas. They were first legally introduced into Texas in 1981. At that time 270,000 were released in Lake Conroe as part of a scientific experiment to determine their usefulness, effectiveness, and safety. Total elimination of aquatic vegetation was soon achieved.

Currently, grass carp are allowed for vegetation control in 35 states. Of those only 10 allow diploid fish. As a result of diploid stocking in the central U.S., grass carp are reproducing in the Mississippi and Missouri rivers, as well as in a number of major tributaries. There is the possibility that reproduction may occur in some Texas waters if diploid fish are allowed in the state. Therefore, to guard against the possibility of unchecked reproduction (and the environmental problems that could result), the Texas Parks & Wildlife Department will allow the use of triploid grass carp only.

Frequently Asked Questions

How many grass carp should I stock?

The department generally allows stockings up to 7 fish per acre. The decision was made for two reasons. First, fish stocked at low densities are generally effective (although results may not be realized in very short periods of time, as with high stocking densities), especially when stocked at the proper time of year or in conjunction with other control techniques. Second, if grass carp can be used effectively at low stocking densities, the probability of environmental damage as a result of their introduction may be substantially lessened.

When is the best time to stock my grass carp?

The best time to stock grass carp is after vegetation has already been reduced by some other means (e.g., in the winter after a natural die-off, or after a chemical treatment). Grass carp may then be stocked at low densities and provide effective control over a long period of time.

Are grass carp good in all situations?

NO. Grass carp should not be stocked in ponds where aquatic vegetation is important. For example, ducks may utilize aquatic vegetation heavily; if ducks are important do not use grass carp.

Is some vegetation good for my pond?

Some vegetation is very good for a pond, in terms of increasing oxygen levels, increasing water clarity, providing nursery habitat for young fish, providing a refuge from predators, and providing fish food (many of the bugs that some fish eat are closely

associated with vegetation). Therefore, if vegetation covers only 10-20% of a pond, control may be unnecessary.

Will grass carp eat all plants equally?

NO. If submerged vegetation is the major problem, grass carp may be a viable control option. However, if emergent or floating leaved vegetation is of concern, grass carp may be of much less use. Grass carp exhibit strong feeding preferences, and almost invariably floating leaved vegetation is very low on the preference scale. For instance, grass carp will usually not eat water hyacinth unless it is the last plant species available for consumption. Therefore, if water hyacinth is the problem, chemical control may be a better alternative than grass carp.

Will grass carp affect water quality?

After aquatic vegetation is removed turbidity (murkiness) may increase. Aquatic vegetation tends to reduce turbulence so that sand and mud are not stirred up into the water as easily. Aquatic vegetation also utilizes nutrients which may otherwise be used by phytoplankton (microscopic plants which float in the water). When large plants disappear, phytoplankton may flourish and decrease visibility in the water.

How do I find out how large my pond is?

If you do not know how large your pond is you may contact either this department, the Soil Conservation Service or an Agricultural Extension office to inquire about professional help.

How often can I stock grass carp?

The department will usually allow triploid grass carp stockings once in five years. Therefore, it is important for pond owners to take steps to ensure that fish remain where they are stocked, and do not migrate away.

What size should I stock?

In general, triploid grass carp sold for vegetation control are 8-10 inches in length. However, smaller fish can be purchased. If large predators such as largemouth bass are present at a proposed stocking site, grass carp no smaller than 8 inches should be used.