Aquatic weed management alternatives for tropical areas

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Weed control and management is a difficult and often never-ending process. Most weed control efforts, both public and commercial ventures, are confined to row-crop production agriculture. Unfortunately, weeds exist in many other areas including native habitats, roadsides, home landscapes, and aquatic situations.

Weed management in aquatic and/or wetland areas comprises a small portion of the total effort in weed science but encompasses tremendous challenges not encountered in traditional weed control. Most aquatic situations, whether it is a lake, pond, or river, is a resource that has more than one use. Bodies of water such as these are used for potable drinking water, irrigation, or recreational uses such as boating, swimming, waterfowl hunting, or angling. Each of these uses dictates specific guidelines or requirements, especially as it relates to vegetation management. For instance, swimmers and boaters prefer clear and weed-free water. However, many fishermen and hunters prefer dense aquatic vegetation for fish and waterfowl habitats. Because of these multiple uses and the often-opposing management strategies, each body of water must be managed separately and uniquely. The intent of this manuscript is to describe the various methods used for managing vegetation for various water uses in the United States. Herbicides are listed by common name and are registered for use in aquatic habitats by the United States Environmental Protection Agency.

Aquatic weeds are often described or categorized by their growth habit. These including floating plants, ditchbank or emergent plants, and submersed plants. Floating weeds are free-floating on the water surface and include *Eichornia crassipes*, *Pistia stratioties*, *Lemna spp.*, *Salvina rotundifolia*, *Azolla caroliniana*, and others. Emergent plants are rooted to the soil along the shoreline and often extend into the water, generally along the water surface. Emergent weeds include *Alternanthera philoxeroides*, *Sagittaria spp.*, *Typha spp.*, *Pontederia lanceolata*, *Polygonium spp.*, *Panicum repens*, and *Hydrocotyle ranunculoides*. Other emergent species include *Lotus* and *Nuphar spp.* which emerge through the water column and form leaves and flowers on the surface. Submersed plants also arise from the hydrosoil but rarely emerge above the surface. Examples of submersed weeds include *Egeria densa, Hydrilla verticillata, Ceratophyllum demersum, Vallisneria americana, Najas spp., Potamogeton spp.,* and *Myriophyllum spp.*

Nutrient management, if possible, is one of the most effective ways to control aquatic vegetation. Excessive nutrient loads lead to eutrophic or hyper-eutrophic conditions, where a continuous alga is present. These conditions prevent the growth of most other plants (macrophytes) and exclude certain aquatic fauna. The primary way to reduce nutrient load is to decrease the amount of fertilizers or manures applied to the land surrounding the body of water or in the water body itself. Nitrogen and phosphorus are the main nutrients that have been shown to cause problems with excessive plant and algal growth.

Drawdowns or water removal from a small area is very useful and effective in controlling many aquatic plants. This will also aid in the reduction of mud and nutrient-rich sediment that may be contributing to undesirable plant growth. However, drawdowns are only effective if the target plants remain desiccated for a sufficient amount of time. Moreover, some plants are not controlled using this method. For example, *Egeria densa* can be effectively controlled by drawdown, while *Hydrilla verticillata*, a similar plant in growth habit, is not. Drawdowns may also create new problems where emergent species spread into the drawdown area. A particular problem species is *Typha* in situations where extended drawdown periods are used.

Mechanical control involves the physical removal of plants from the water body and can be effective for smaller sites. Removal can be accomplished by hand or through the use of specialized equipment. For many

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ponds or still pools, floating weeds can be netted and dragged off for disposal. Nets or screens can also be used to prevent larger floating plants such as *Eichornia crassipes* or *Pistia stratiotes* from entering an area. Commercially manufactured aquatic weed harvesters are sometimes used in larger bodies of water. Depending on type, these machines can harvest floating or submersed plants. However, they are often expensive, slow and lack the capacity to be effective in many areas but remain an option for special situations.

Biological control is often considered to be the 'ideal' weed control method. This method employs the use of biological agents such as insects or plant diseases to specifically attack the target pest plant. Biological control fluctuates with the growth of the pest plant, keeping growth in check. Furthermore, host specific biological control agents do not damage desirable plant species. Biological control agents must be rigorously tested for specificity against the pest organism in the environment and to insure that the organism will not harm off-target plant species. The most striking example of a successful biological control effort is the control of *Alternanthera philoxeroides* with the flea beetle *Agasicles hygrophila*. Grass carp (*Ctenopharyngodon idella*) is an example of a non-specific biological control organism that is sometimes used in the United States mainly for the control of submersed plants. Sterile (triploid) fish are used that cannot reproduce. Grass carp are non-specific and will eventually remove all submersed vegetation from a body of water if stocking rates are sufficient. They generally have little effect on larger floating plants or ditch-bank weeds. The University of Florida Cooperative Extension recommends three possible management strategies using grass carp. These include: 1) complete vegetation removal within one to two years with a heavy stocking rate; 2) winter stocking before the spring growth of weeds begins, using fewer fish to maintain a lesser amount of vegetation in the system and increasing the grass carp population as needed and; 3) integrated control using herbicides to obtain desired levels quickly and stocking grass carp to maintain this level. They caution that it is easier to stock additional carp than remove unwanted fish.

Aquatic weed management utilizing herbicides is the most common method of control for several reasons. These include a high degree of selectivity, safety to desirable aquatic organisms, effective control of perennial emergent species, and cost-effectiveness. Currently there are six herbicides - active ingredients that are labeled for weed control in aquatic areas (directly into a body of water) in Florida. There are also three additional herbicides that can be used in wetland, ditch-bank or canal bank areas. The following discussion focuses on these materials and their uses for weed control. This discussion relates to their use in the United States and Florida, and may not apply to other areas. It is necessary to check with the proper authority for labeled uses and restrictions in your area.

Copper. Copper products include copper sulfate and copper chelates (alkanolamine, triethanolamine, and ethylenediamine complexes). Copper can be used in most aquatic systems including lakes, ponds, and reservoirs. Copper is considered to be contact in activity and interferes with photosynthesis and respiration. Copper provides good control of both filamentous and planktonic algae and also enhances the control of several submersed species with the herbicide diquat. Copper sulfate can be toxic to fish while the chelated forms are less toxic. Copper sulfate is very corrosive to steel and galvanized steel.

Diquat. Diquat can be used in a wide range of water systems including lakes, rivers, ponds, canal and reservoirs. Diquat is contact in activity, quick acting and provides excellent control of many submersed and floating weeds. Diquat is often used to control *Lemna spp.*, *Azolla caroliniana*, *Pistia stratiotes* and *Eichornia crassipes*. Diquat also provides excellent control of several submersed species including *Ceratophyllum demersum, Hydrilla verticillata, Potamogeton spp., Utricularia spp.,* and *Cabomba caroliniana*. The addition of copper can enhance control.

Endothall. There are currently two formulations of endothall registered for use including the dipotassium salt and alkylamine salts. Endothall can be used in irrigation and drainage canals and in ponds and lakes. Endothall is contact in activity and does not persist in the aquatic environment with rapid microbial breakdown. The alkylamine salt provides excellent control of filamentous algae and submersed weeds. However, this formulation is highly toxic to fish and should not be used where fish mortality is a concern except for spot treatments.

The dipotassium salt is not effective on algae but does provide good control of submersed weeds without fish toxicity problems.

Fluridone. Fluridone can be used in most aquatic systems including lakes, ponds, ditches, canals and reservoirs. It is applied as a liquid or slow release pellet formulation depending on target species and sediment type. Fluridone provides excellent control of many submersed species including: *Hydrilla veriticillata, Najas guadalupensis, Ceratophyllum demersum, Potamogeton spp., Utricularia spp.* and *Cabomba spp.*. In addition, fluridone has good activity on the floating species *Lemna, and Azolla.* This herbicide also provides good control of emergent species such as *Nuphar, Lotus* and *Nymphaea odorata* at high application rates. Fluridone is slow acting, which minimizes the potential for fish mortality as a result of lowered dissolved oxygen following weed control operations. It prevents the formation of carotenoids which results in the photo-destruction of chlorophyll. Effected plants appear bleached or white, especially at the growing tips.

2,4-D. This herbicide has been registered for many years and provides good control of many emergent species and several submersed aquatic weeds. Liquid formulations (primarily amines) are used for floating and emergent weeds and are considered the standard for *Eichornia crassipes* control. Granular formulations of 2,4-D are used for submersed weed control and provide excellent control of *Myriophyllum spp.* 2,4-D causes abnormal growth in susceptible species and is classified as an auxin (plant hormone involved in phototrophic responses and bud dormancy) mimic.

Glyphosate. Glyphosate is labeled for use in ponds, lakes, rivers, canal and reservoirs. It is non-selective, injuring most all plants contacted by spray. Glyphosate prevents the formation of essential amino acids within the plant, causing a cessation of growth, starvation and eventual plant death. This compound is inactivated in water and does not control submersed species. It has good to excellent activity on emergent, ditch-bank and certain floating vegetation. Glyphosate is one of few compounds that provides adequate control of *Typha spp.*

Diuron. Diuron is registered for use in *drained* ditches and canals and for algae control in commercial ornamental fish ponds. This compound prevents photosynthesis and is absorbed by plants roots and translocated via the xylem to shoots and leaves. It is highly effective as a pre-emergence herbicide for several submersed species.

Imazapyr. Imazapyr is registered for use only on non-irrigation ditch-banks and canals. It is absorbed by roots and shoots and prevents the formation of essential amino acids necessary for plant growth. Affected plants cease growth and eventually die. Imazapyr provides good control of many emergent and ditch-bank weeds.

Triclopyr. Triclopyr is registered for use only on non-irrigation ditch-banks and canals. It is primarily absorbed by the foliage and is similar in activity to 2,4-D. It targets broadleaf weeds and provides excellent control of *Pontederia spp., Alternanthera philoxeroides and Polygonum spp.* As with any weed control method, pre-cautions must be taken with regard to fish safety. When a large amount of plant (weed) material is killed, the decaying plants remove oxygen from the water - creating biological oxygen demand. If the level of plant material that has been controlled is too extensive, oxygen levels may drop below those needed for fish. Therefore the following rules should be kept in mind if fish mortality is a concern: 1) avoid treating submersed vegetation or algae with contact herbicides on cloudy days; 2) treat less than one third of a heavily infested (greater than 80%) body of water; and 3) treat early in the season when water temperature is lower if possible and keep vegetation at low densities with frequent applications if possible.

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Table 1. Effectiveness of Herbicides for Aquatic Weed Control

	Endothall		Diquat	2,4-D	Copper	Fluridone Compounds	Glyphosate
	Potassium Salt	Amine					
FLOATING PLANTS							
Lemna spp.	*	*	G	F	*	E	*
Wolffia spp.	*	*	*	*	*	F	*
Alternanthera philoxeroides	*	*	*	F	*	F	G
SUBMERSED PLANTS							
Utricularia spp.	F	F	G	F	*	G	*
Egeria densa	*	*	E	*	F	G	*
Ceratophyllum spp.	E	E	E	G	*	E	*
Hydrilla verticillata	E	E	E	*	F	E	*
Myriophyllum aquaticum	E	E	G	E	*	F	*
Potamogeton spp.	E	E	G	*	*	F	*
Najas minor	E	E	E	*	*	E	*
Najas quadalupensis	G	G	E	*	*	G	*
Eleocharis baldwinii	*	*	*	*	*	G	*
Myriophyllum heterophyllum	G	G	G	E	*	G	*
EMERSED PLANTS							
Nelumbo lutea	*	*	*	G	*	G	G
Typha spp.	*	*	G	F	*	F	E
Nymphea odorata	*	*	*	G	*	G	E
Jancus spp.	*	*	*	F	*	*	G
Nuphar spp.	*	*	*	F	*	G	E
Hydrocotyle spp.	*	*	F	G	*	*	E
FILAMENTOUS ALGAE	*	G	G	*	G	*	*

* = Not recommended; G = Good (80 to 90% control); F = Fair (70 to 80 % control); E = Excellent (90 to 100% control).

Table 2. Waiting Period (Days) Before Using Water After Application of Herbicides for Aquatic Weed Control

Common Herbicides Name	Irrigation	Fish Consumption	Watering Livestock	Swimming
Copper	NR	NR	NR	NR
2,4-D	Water uses restrictions vary by formulation and manufacturer. In general, if water is used for irrigating sensitive crops, 2,4-D should not be used. Turfgrasses are generally tolerant to low concentration of 2,4-D.			
Diquat	5 (food crops)	NR	1	NR
Endothall	7-14	3	14	1
Fluridone	7-30	NR	NR	NR
Glyphosate	NR	NR	NR	NR

NR = no restrictions