Summary of biological management methods for aquatic plants.

Management Method	Description	Advantages	Disadvantages	Systems where used effectively	Plant species response
Grass Carp / White Amur	Herbivorous Fish	Long-term (decades), relatively inexpensive	Cannot control feeding sites, difficult to contain in water body, tendency for "all or none" community response, persistent	Isolated water bodies, effective against hydrilla and other preferred species. Operational.	Fish have strong preference for hydrilla and some native plants, avoid Eurasian watermilfoil, generally do not prefer floating plants
Neochetina spp.	Waterhyacinth weevils	Species selective	Not effective in reducing areal coverage in many situations	Released in Florida, Gulf Coast states. (Developmental)	Leaf scars, some reduction in growth
Hydrellia spp. *Bagous* spp.	Hydrilla fly, hydrilla stem weevil	Species Selective	Has not yet been established	Released in Florida, Alabama, Texas. (Research)	Limited
Euhrychiopsis lecontei and other native insects	Weevil - native or naturalized	Already established in U.S.	Less selective, currently under R&D	Currently under study in Vermont, Minnesota (Research)	Plants loose buoyancy, weevil interferes with transfer of carbohydrates
Mycoleptodiscus terrestris (Mt)	Fungal pathogen; acts as a contact bioherbicide	Low dispersion, fairly broad spectrum	Expense, cross-contamination, inconsistent viability and virulence of formulation	Under R&D for both Eurasian watermilfoil and hydrilla	"Contact Bioherbicide", plants rapidly fall apart, but regrow from roots
Native Plant Community Restoration	Planting of desirable native plant species or community	Provides habitat, may slow reinvasion or initial invasion	Expensive, techniques still under development	Under R&D around the country	Native plants provide ecosystem benefits, slow invasion

Use suggestions for US Environmental Protection Agency-approved aquatic herbicides.

Compound	Exposure Time (Water)	Advantages	Disadvantages	Systems where used effectively	Plant species response
Complexed Copper	Intermediate (18-72 hours)	Inexpensive, rapid action, approved for drinking water	Does not biodegrade, but biologically inactive in sediments	Lakes as algicide, herbicide in higher exchange areas	Broad-spectrum, acts in 7-10 days or up to 4-6 weeks
2,4-D	Intermediate (18-72 hours)	Inexpensive, systemic	Public perception	Waterhyacinth and Eurasian watermilfoil control, Lakes and slow-flow areas, purple loosestrife	Selective to broad-leaves, acts in 5-7 days up to 2 weeks
Diquat	Short (12-36 hours)	Rapid action, limited drift	Does not affect underground portions	Shoreline, localized treatments, higher exchange rate areas	Broad-spectrum, acts in 7 days
Endothall	Short (12-36 hours)	Rapid action, limited drift	Does not affect underground portions	Shoreline, localized treatments, higher exchange rate areas	Broad spectrum, acts in 7-14 days
Fluridone	Very long (30-60 days)	Very low dosage required, few label restrictions, systemic	Very long contact period	Small lakes, slow flowing systems	Broad spectrum, acts in 30-90 days
Glyphosate	Not Applicable	Widely used, few label restrictions, systemic	Very slow action, no submersed control	Nature preserves and refuges; Emergent and floating-leaved plants only	Broad spectrum, acts in 7-10 days, up to 4 weeks
Triclopyr	Intermediate (12-60 hours)	Selective, systemic	Not currently labeled for general aquatic use	Lakes and slow-flow areas, purple loosestrife	Selective to broad-leaves, acts in 5-7 days, up to 2 weeks

Characteristics of U.S. Environmental Protection Agency-approved aquatic herbicides.

Compound	Trade Name	Company	Formulation; Contact vs. Systemic	Mode of Action	Bluegill 96 hr. LC_{50} (mg/L)
Complexed Copper	Cutrine-Plus Komeen Koplex K-Tea	Applied Biochemists (Cutrine) Griffin Corporation	Various complexing agents with copper, superior to $CuSO_4$ Systemic	Plant cell toxicant	1250
2,4-D	Aqua-Kleen Weedar-64 Wee-Rhap A-6D Several Others	Applied Biochemists Rhone-Poulenc Inter-Ag	BEE salt DMA liquid IEE liquid Systemic	Selective plant-growth regulator	1.1-1.3 123-230
Diquat	Reward	Zeneca	Liquid Contact	Disrupts plant cell membrane integrity	10-140
Endothall	Aquathol K Hydrothal 191 Aquathol granular	Elf Atochem (All Formulations)	Liquid or granular Contact	Inactivates plant protein synthesis	125 0.06-0.2
Fluridone	Sonar AS Sonar SRP	SePRO	Liquid or granular Systemic	Disrupts carotenoid synthesis, causing bleaching of chlorophyll	9-12.5
Glyphosate	Rodeo	Monsanto	Liquid Systemic	Disrupts synthesis of phenylalanine	4.2-14
Triclopyr	Garlon 3A (EUP) Renovate (EUP)	SePRO	Liquid Systemic	Selective plant growth regulator	148

Application restrictions of US Environmental Protection Agency-approved aquatic herbicides.

Compound	Persistence (half-life, in days)	Maximum Application Rate	Maximum water concentration	Safety Factor	Application Notes	WES Recommended for
Complexed Copper	3	1.5 gal/ft/acre	1.0 mg/L	>50	Algicide / Herbicide	Hydrilla, other submersed spp.
2,4-D	7.5	0.5 gal/acre	2.0 mg/L	>25	Some formulations for special permits only	Eurasian watermilfoil, water-hyacinth, and others
Diquat	1-7	2 gal/acre	2 mg/L	5	Binds with particles (suspended solids) in water	All
Endothall	4-7	13 gal/acre	5.0 mg/L	>10 (Aquathol) <1.0 (Hydrothal)	Fish are sensitive to Hydrothal 191 - over 1 mg/L may cause fish kill	All submersed spp.
Fluridone	21	1.1 qt/acre	0.15 mg/L (150 ppb)	>20	Applications have been successful below 10 ppb	Most submersed spp.
Glyphosate	14	2 gal/acre	0.2 mg/L	>20	Aerial portions only - not for submersed plants	Most emergent and floating spp.
Triclopyr	na	na	2.5 mg/L	>50	EUP/Special Needs only - US EPA label expected in 1997	Eurasian watermilfoil, water-hyacinth, others

Characteristics of physical management techniques.

Management Method	Description	Advantages	Disadvantages	Systems where used effectively	Plant Species Response
Dredging/ Sediment Removal	Use mechanical sediment dredge to remove sediments, deepen water	Creates deeper water, very long-term results	Very expensive, must deal with dredge sediment	Shallow ponds and lakes, particularly those filled in by sedimentation	Often creates large usable areas of lake, not selective
Drawdown	"De-water" a lake or river for an extended period of time	Inexpensive, very effective, moderate-term	Can have severe environmental impacts, severe recreational/ riparian user effects	Only useful for manmade lakes or regulated rivers with a dam or water control structure	Selective based on perennation strategy; effective on evergreen perennials, less effective on herbaceous perennials
Benthic Barrier	Use natural or synthetic materials to cover plants	Direct and effective, may last several seasons	Expensive and small-scale, nonselective	Around docks, boat launches, swimming areas, and other small, intensive use areas	Nonselective, plant mortality within one month underneath barrier
Shading / Light Attenuation	Reduce light levels by one of several means: dyes, shade cloth, plant trees (rivers)	Generally inexpensive, effective	Nonselective, controls all plants, may not be aesthetically pleasing	Smaller ponds, man-made waterbodies, small streams	Nonselective, but may be long-term
Nutrient Inactivation	Inactivate phosphorus (in particular) using alum	Theoretically possible	Impractical for rooted plants limited by nitrogen	Most useful for controlling phytoplankton by inactivating water column P	Variable

Characteristics of mechanical management techniques.

Management Method	Description	Advantages	Disadvantages	Systems where used effectively	Plant species response
Hand- Cutting/ Pulling	Direct hand pulling or use of hand tools	Low-technology, affordable, can be selective	Labor-intensive, cost is labor-based	Most of the undeveloped world, volunteer labor pools	Very effective in very localized areas
Cutting	Cut weeds with mechanical device (typically boat-mounted sickle bar) without collection	More rapid than harvesting	Large mats of cut weeds may become a health and environmental problem, may spread infestation	Heavily-infested systems	Nonselective, short-term
Harvesting (Cut and Remove)	Mechanical cutting with plant removal	Removes plant biomass	Slower and more expensive than cutting; resuspension of sediments	Widespread use with chronic plant problems	Like cutting, it is cosmetic, non-selective short-term
Grinder or "Juicer" (Cut and Grind)	Mechanical cutting with grinding of plant material and in-lake disposal	Immediate relief of plant nuisance, no disposal	Resuspension of sediments, decomposition of plants in lake, floating plant material	Useful for chronic plant problems where disposal of plants is problematic	Like cutting and harvesting, it is cosmetic, non-selective short-term
Diver-Operated Suction Harvester	Vacuum lift used to remove plant stems, roots, leaves, sediment left in place	Moderately selective (based on visibility and operator), longer-term	Slow and cost-intensive	Useful for smaller nuisance plant populations in which plant density is moderate	Typically have minimal regrowth for Eurasian watermilfoil; not effective for tuber-setting hydrilla
Rotovating	Cultivator on long arm for tilling aquatic sediments	Disrupts Eurasian watermilfoil stem bases, intermediate-term results	May spread large numbers of fragments; resuspension of sediments	Used extensively in the Pacific Northwest and British Columbia, with mixed results	Effective in disrupting Eurasian watermilfoil dense stands; not selective and only intermediate-term