Invasive Aquatic Plants: A Threat to Mississippi Water Resources

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Abstract

Invasive aquatic plants are an ever-growing nuisance to water resources in Mississippi and the rest of the United States. These plants are generally introduced from other parts of the world, some for beneficial or horticultural uses. Once introduced, they can interfere with navigation, impede water flow, increase flood risk, reduce hydropower generation, and increase evapotranspirational losses from surface waters. Invasive species also pose direct threats to ecosystems processes and biodiversity. Although there are at least twenty different species of nonnative plants currently in Mississippi, with another eight perched on our doorstep, four species cause the bulk of nuisance problems in large surface waters: Eurasian watermilfoil (*Myriophyllum spicatum*), hydrilla (*Hydrilla verticillata*), waterhyacinth (*Eichhornia crassipes*), and water primrose (*Ludwigia hexapetala*). One additional species (giant salvinia (*Salvinia molesta*)) is a source of significant national concern. I will discuss general modes of introduction to the United States, dispersal to water resources, spread throughout a water resource once a plant is introduced to the system, and effects of large stands on water resource quality. General management approaches include prevention of infestation, and biological, chemical, mechanical, and physical control techniques of plant infestations. While many regulatory agencies oppose management for fear of potential adverse effects of the management techniques, in general the failure to prevent widespread growth of these species causes more harm to the resource than effective management.

Keywords: Ecology, Management & Planning, Recreation, Wetlands

Introduction

Aquatic plants are a key component to aquatic ecosystems and the services they provide. Aquatic plants stabilize sediments and shorelines, reduce turbidity, provide habitat for aquatic organisms, and food for waterfowl (Madsen 1997). In most instances, extensive nuisance growths of aquatic plants are not caused by cultural eutrophication, but by the introduction of invasive plants species. Invasive species are typically introduced from other continents through horticultural or aquaria trade, but have become a widespread problem in the United States (Huber et al. 2002, Mullin et al. 2000). Invasive species impact both human uses and ecological attributes of water resources.

Invasive species directly impact human uses of water resources through obstructing commercial and recreational boat traffic, clogging hydropower generation turbines, and increasing flood risk (Madsen 1997). Invasive plants have also impacted societal values of water resources indirectly through increasing the spread of insect-borne disease and decreasing property values (Madsen 1997). The economic cost of invasive aquatic plant management is considerable, and estimated at over $100M per year in the United States

(Pimentel et al. 2000). Despite these high costs, the benefits are generally considered to be substantially more than the cost (Rockwell 2003).

Invasive species also affect the ecological value of water resources through degradation of water quality under dense mats of vegetation, which decreases oxygen concentrations and increases internal loading of nutrients (Madsen 1997). Dense mats of invasive plants also reduce species diversity, suppress native plant species, and cause localized extinction of native plants (Madsen et al. 1991, Madsen 1994). Invasive species are considered a leading cause of species extinction worldwide (Pimentel et al. 2000).

In this review, I will discuss the methods by which invasive species are introduced and spread within the United States, the invasive aquatic plants found in Mississippi and those on the verge of introduction, the five highest-profile invasive aquatic plants in Mississippi, and lastly provide an overview of how these species can be managed.

Introduction and Dispersal of Invasive Aquatic Plants

As with other invasive species, the introduction and spread of invasive aquatic plants has been largely the result of human activity, both intentional and accidental. The initial introduction of species from one continent to the next has been overwhelmingly at the hands of humans (Figure 1). Typical examples of this type of introduction are through importation of aquaculture, ornamental horticultural, and aquaria specimens (Huber et al. 2002, Kay and Hoyle 2001). Even interstate introductions have been largely due to human activity, though some examples of interstate transport of invasive aquatic plants have been observed. In addition to the above modes of human transport, incidental trailering on boats and accidental or intentional shipping in horticultural specimens may be added (Johnstone et al. 1985, Madeira et al. 2000). At the local scale of within a lake or between adjacent lakes of a given watershed, the natural dispersal processes are typically more important than human carriers. Natural dispersal mechanisms include plant movement by wind or water movement and animal carriers (Madsen and Smith 1997, 1999, Madsen et al. 1988, Owens et al. 2001).

Logically, the best way to avoid a problem is to prevent the introduction of invasive aquatic plants, and to do this through modifying those human activities that introduce and spread invasive plants. For instance, educational efforts in numerous states has been successful in reducing the rate of Eurasian watermilfoil spread through boat inspections, signage at boat launches, media awareness, and traffic inspections (Exotic Species Program, 2004).

Invasive Species In or Near Mississippi

Twenty-one invasive aquatic and wetland species have been sighted in Mississippi, while another seven are in states adjacent to Mississippi (Table 1). Water resource management professionals should be alert to the presence of these species in their area. While I will highlight only a few of the more widespread of these species, that is not meant to diminish the potential for invasiveness and deleterious impact of any of the species on this list, or not mentioned. So, in no particular order, I will highlight five species of concern: Eurasian watermilfoil, giant salvinia, hydrilla, waterhyacinth, and water primrose.

Eurasian watermilfoil (*Myriophyllum spicatum* L.) is a submersed plant native to Europe and Asia, growing completely underwater but often forming a dense canopy near the water's surface (Madsen 1997). It is an evergreen perennial, with green shoots to be found throughout the year. Eurasian watermilfoil spreads through the prolific formation of stem fragments, as well as by runners, stolons, and rhizomes (Madsen et al. 1988). The impact of Eurasian watermilfoil on native plant communities has been documented, as well as the natural regeneration of native plant communities after management of Eurasian watermilfoil populations (Madsen et al. 1991, Getsinger et al. 1997). Eurasian watermilfoil is currently found throughout almost all the continental United States (Jacono and Richerson 2003).

Giant salvinia (*Salvinia molesta* D.S. Mitchell) is a perennial floating fern from South America, which has become a severe nuisance in tropical regions of Africa, Australia, and some portions of the United States (Oliver 1993, Nelson et al. 2001). Giant salvinia is very difficult to control, and is resistant to drying and short freezing events (Oliver 1993). In the United States, it is found in isolated areas of California, Arizona, Texas, Louisiana, Alabama, Georgia, Florida, and North and South Carolina. A small population was found in Mississippi, but was successfully controlled. If observed, it should be vigorously eradicated before it can spread to more waters in Mississippi. Giant salvinia is easily confused with the common salvinia (*Salvinia minima* Baker), which is a widespread invasive species in the southeastern United States.

Hydrilla (*Hydrilla verticillata* (L.f.) Michx.) is a submersed herbaceous perennial plant that has become the most severe nuisance submersed species in the southeastern states, in many instances outcompeting Eurasian watermilfoil (AERF 2004). It is spread by tubers, turions, and stem fragments (Madsen and Smith 1999). Hydrilla is found in numerous states from Maine along the coast to Texas, and in Washington State, California, and Arizona. While not as widespread in Mississippi, significant populations do occur in the Tennessee-Tombigbee waterway and in southwestern Mississippi.

Waterhyacinth (*Eichhornia crassipes* (Mart.) Solms) is a perennial plant composed of floating rosettes that reproduces vigorously by growth from stolons (Madsen 1993, Madsen et al. 1993). A native of Central and South America, it remains the most common nuisance aquatic plant in tropical regions. In the United States, it occurs in the southern Atlantic and Gulf Coast states and in California (Mullin et al. 2000). Waterhyacinth is widespread in Mississippi in wetlands and permanent lakes, regardless of water quality.

Water primrose (formerly *Ludwigia uruguayensis* (Camb.) Hara; now separated into *Ludwigia hexapetala* (Hook & Arn) Zardini, Gu & Raven and *Ludwigia grandiflora* (M. Micheli) Greuter & Burdet) is an herbaceous perennial plant that grows as either an emergent or floating-stem growth forms. Native to South America, this species is a common nuisance in shallow wetlands, ponds, and ditches (Crow and Hellquist 2000). Little is known about their biology and ecology. These species grow throughout the southern United States (Crow and Hellquist 2000).

Seven invasive aquatic plants of potential concern to Mississippi grow in adjacent states (Table 1). Of these, I will specifically mention two: Roundleaf toothcup and wetland nightshade.

Roundleaf toothcup (*Rotala rotundifolia*) is an emergent herbaceous perennial currently found in southern Florida and an isolated population near Tuscaloosa, Alabama (USGS, 2003). Although little is known concerning its biology or potential for spread, it is related to the widespread wetland nuisance purple loosestrife (*Lythrum salicaria* L.), which alone is cause for concern.

Wetland nightshade (*Solanum tampicense* Dunal) is an emergent herbaceous perennial plant currently found in south and central Florida (Richerson and Jacono 2003). Wetland nightshade forms dense stands that suppress native species, and have prickly stems and leaves (Fox and Bryson 1998, Fox and Wigginton 1996).

Management Techniques for Invasive Aquatic Plants

Four categories of management techniques will be discussed for aquatic plants: Biological, chemical, mechanical, and physical control techniques (Madsen 2000).

Biological Control. Biological control techniques include herbivorous insects, grass carp, and pathogens. Biological control agents can either be found using the classical approach, through surveys of the native range of invasive plants; or through examining naturalized populations of the plant and searching for naturalized insects or pathogens. The latter approach often discovers generalist feeders or pathogens, so the naturalized populations tend to be less selective. While research has been conducted on biological control for four of our five major weed concerns, none of the weeds have consistent insect or pathogen controls (Table 2, Madsen 2000). Grass carp are effective for controlling hydrilla, but have other environmental concerns regarding their use.

Chemical Control. A total of eight active ingredients are approved for use on invasive aquatic plants by the US Environmental Protection Agency (Table 3). Aquatic herbicides can be divided into contact herbicides, which are more rapid in their effect but are not moved throughout the plant and thus tend to allow plants to regrow, and systemic herbicides, which are moved throughout the plant but tend to have a slower response. In general, systemic herbicides are preferred for use over contact herbicides for managing invasive species. For the safety of applicators, human users of water resources, and the environment, it is imperative that the label instructions be followed. Herbicides are safe for use in the environment when used according to label instructions.

Aquatic herbicides are not sold with surfactants in the formulation, so surfactants safe for use in aquatic environments should be added to the spray tank when used to control emergent and floating plants. Generally, adjuvants are not needed for submersed plant control.

The broadleaf herbicide 2,4-D is widely used for control of Eurasian watermilfoil, waterhyacinth, and water primrose. Since it is selective for broadleaf plants and systemic, it is a particularly good choice when it is desirable to allow native narrowleaf species to grow.

Complexed copper solutions are widely used for control of algal problems and, while labeled for use on vascular plants, copper rarely works well when used by alone on weeds. It has been used with other herbicides to enhance their effectiveness, or with other herbicides to control simultaneous problems with algae.

Diquat is a widely used broad-spectrum contact herbicide for invasive weeds, both emergent and submersed. While it works well on most species for initial kill, plants generally grow back within four to six weeks. For some instances, however, it is the only herbicide feasible for environmental and species effectiveness considerations.

Endothall is a broad-spectrum contact herbicide used for submersed invasive weeds and algae. Endothall is often used in more turbid water, since it does not have the tendency to absorb on silt particles.

Fluridone is a broad-spectrum systemic herbicide widely used for control of submersed species, and in some instances is effective on floating plants such as giant salvinia and duckweed. Fluridone is applied to the water, and absorbed by leaves or roots of the plants.

Glyphosate is a broad-spectrum systemic herbicide used for control of emergent or floating plants, but is not effective on submersed vegetation since it is readily absorbed by particles in the water. Glyphosate should be applied to the vegetation above the water.

Imazapyr is a newly labeled herbicide for aquatic use, though it has been used extensively in rights of way and forestry. A broad-spectrum systemic herbicide, it is slow acting but effective on large perennial and woody plants. Imazapyr should be applied to emergent or floating leaves or stems.

Triclopyr has a relatively new aquatic use label, though it also has been widely used for woody vegetation control in the past. Triclopyr is a broadleaf selective systemic herbicide, for use on both submerged and emergent species. It is a good choice for Eurasian watermilfoil, waterhyacinth, and water primrose.

Mechanical Control. Mechanical control techniques involve operations that remove plant material, either by hand or through the use of tools, as a means of control (Table 4). Generally, these techniques result in immediate nuisance relief, but tend to allow plants to regrow quickly.

Hand pulling is the most widely used technique in the world, and is surprisingly common for use on very small infestations in the United States. It is generally inefficient and expensive, but may work if only individual plants occur that have not formed a dense root mass.

Cutting involves the use of boats or other equipment with an emersed or submersible cutting bar. Generally, cutting alone is discouraged in that it leaves a large amount of biomass in the water to decompose, but in some situations it can be appropriate.

Harvesting goes beyond cutting in that the equipment collects the plant material that is cut, allowing on-land disposal. While this removes the nuisance problem, it can create a solid waste problem. Aquatic plants, being approximately 92% water, are not fit for food or compost, resulting in a waste that is slow to dry.

Diver-operated suction harvesting (or diver operated suction dredging) refers to a process in which SCUBA divers use a portable suction nozzle to remove rooted submersed plant material. While this results in fairly long-term and selective control of nuisance plants, it is very slow and expensive (Eichler et al. 1993).

Rotovating involves the use of a submersible rototilling head on the end of a mechanical arm to till plants in waters up to ten feet deep. Used predominantly for Eurasian watermilfoil control, it can be effective in controlling plants for several years, but creates a large number of fragments and increases water turbidity.

Physical Control. Physical control refers specifically to those techniques that alter the environment to prevent the growth of plants. Growth prevention is usually achieved by reducing light availability, increasing water depth, or changing the substrate to prevent plant growth (Table 5).

Dredging is effective only when it increases the water depth beyond that at which plants can grow, so is most effective for submersed plant management. Given the expense of dredging, it is best used in a larger restoration effort where plant control is a secondary benefit.

Drawdown is one of the least expensive and, for some species, most effective management techniques – if a water control structure is already present on a water body. Drawdown involves dewatering a lake or pond, exposing plants to the air. When combined with winter cold or freezing, it can be particularly effective. Drawdown works well for Eurasian watermilfoil and, to a lesser extent, waterhyacinth; but is ineffective against the other species.

Benthic barrier involves the placement of an impermeable layer on the bottom, to prevent plants from rooting in the sediment. Generally, the barrier is a plastic mat or sheet, but a number of other materials have been used. Benthic barriers are effective for submersed plants, but ineffective for the floating species like giant salvinia, waterhyacinth, and water primrose.

Shading is a widely used technique that can be implemented using either synthetic dyes or additives to the water, in the case of submersed plants, or through encouraging tree growth along ponds or canals for control of all species. The application of this technique is somewhat limited in larger lakes.

Nutrient inactivation is a widely used practice for control of free-floating algae, usually involving the use of alum to bind phosphorus in the water (Welch and Cooke 1999). Nutrient inactivation has not been demonstrated to be effective for management of rooted plants, though the use of alum or other chemicals to bind water column nutrients to control free-floating invasive plants like waterhyacinth and giant salvinia is at least a theoretical possibility. Currently, it would still be considered experimental, and not recommended for operational management of invasive plants.

All four types of techniques should be used to manage invasive plants in the most economical and environmentally compatible manner possible.

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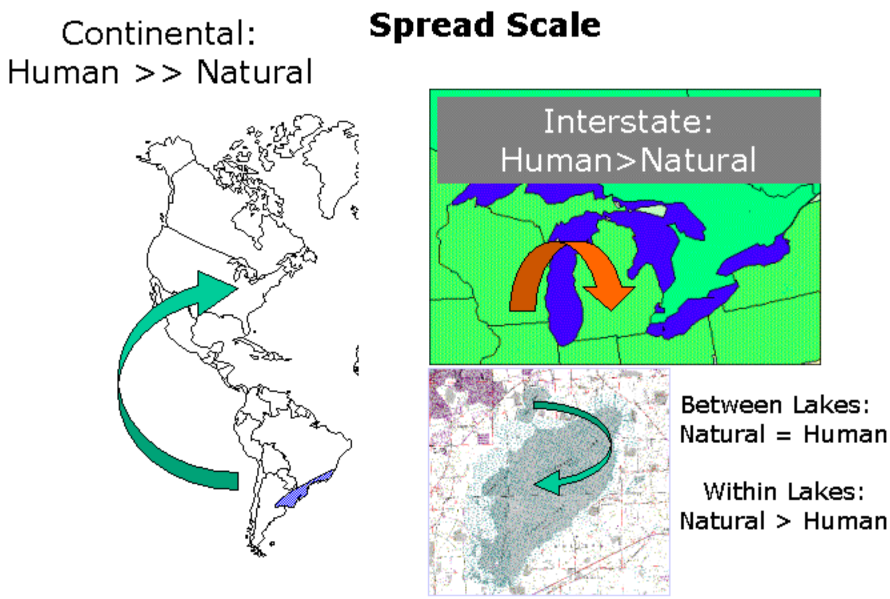

Figure 1. Importance of human versus natural spread mechanisms at the continental, interstate, and local scales.

Table 1. Exotic Invasive Aquatic and Wetland Plants sighted in Mississippi, and those found near Mississippi.

Species sighted in Mississippi

Alligatorweed (*Alternanthera philoxeroides* (Mart.) Griseb.)
Brittle naiad (*Najas minor* Allioni)
Chinese tallow tree (*Sapium sebiferum* (L.) Roxb.)
Common salvinia (*Salvinia minima* Baker)
Curlyleaf pondweed (*Potamogeton crispus* L.)
Deeprooted sedge (*Cyperus entrerianus* Boeck.)
Egeria (*Egeria densa* Planch.)
Eurasian watermilfoil (*Myriophyllum spicatum* L.)
Giant salvinia (*Salvinia molesta* Mitchell)
Hydrilla (*Hydrilla verticillata* Royle)
Marsh dewflower (*Murdannia keisak* (Hassk.) Hand.-Maz.)
Parrotfeather (*Myriophyllum aquaticum* (Vell.) Verde)
Phragmites (*Phragmites australis* (Cav.) Trin.)
Purple loosestrife (*Lythrum salicaria* L.)
Sacred lotus (*Nelumbo nucifera* Gaertn.)
Torpedograss (*Panicum repens* L.)
Waterlettuce (*Pistia stratoites* L.)
Waterhyacinth (*Eichhornia crassipes* (Mart.) Solms)
Water primrose (*Ludwigia hexapetala* (Hook. & Arn.) Zardini, Gu & Raven)
Wild taro (*Colocasia esculenta* (L.) Schott)
Yellow floating heart (*Nymphoides peltata* (Gmel.) Kuntze)

"Watch List" of Species Near Mississippi

Asian marshweed (*Limnophila sessiliflora* (Vahl) Blume)
Indian hygrophila (*Hygrophila polysperma* (Roxb.) T. Anders.)
Melaleuca (*Melaleuca quinquenervia* (Cav.) Blake)
Roundleaf toothcup (*Rotala rotundifolia*)
Wetland nightshade (*Solanum tampicense* Dunal)
White Egyptian lotus (*Nymphaea lotus* L.)
Yellow iris (*Iris pseudacorus* L.)

Table 2. Biological control agents for Mississippi invasive aquatic plants.

Control Technique	Eurasian watermilfoil	Giant salvinia	Hydrilla	Waterhyacinth	Water primrose
Insect	Experimental	Experimental	Poor	Poor	None
Grass Carp	Poor	Poor	Excellent	Poor	Poor
Pathogens	Experimental	None	Experimental	None	None

Table 3. Herbicides for management of Mississippi invasive aquatic plants.

Herbicide	Contact or Systemic	Eurasian watermilfoil	Giant salvinia	Hydrilla	Waterhyacinth	Water primrose
2,4-D	Systemic	Excellent	No	Poor	Excellent	Excellent
Complexed Copper	Contact	Poor	No	Fair	No	No
Diquat	Contact	Good	Excellent	Good	Good	Good
Endothall	Contact	Good	No	Good	No	No
Fluridone	Systemic	Excellent	Good	Excellent	Poor	Poor
Glyphosate	Systemic	No	Excellent	No	Excellent	Excellent
Imazapyr	Systemic	No	Poor	No	Excellent	Excellent
Triclopyr	Systemic	Excellent	No	Poor	Excellent	Excellent

Table 4. Mechanical techniques for Mississippi invasive aquatic plants.

Control Technique	Eurasian watermilfoil	Giant salvinia	Hydrilla	Waterhyacinth	Water primrose
Hand-pulling	Limited	Limited	Limited	Limited	Limited
Cutting	Fair	Poor	Fair	Poor	Fair
Harvesting	Good	Good	Good	Good	Good
Diver-operated Suction Harvesting	Excellent	Poor	Fair	Poor	Poor
Rotovating	Good	Poor	Fair	Poor	Poor

Table 5. Physical control techniques for Mississippi invasive aquatic plants.

Control Technique	Eurasian watermilfoil	Giant salvinia	Hydrilla	Waterhyacinth	Water primrose
Dredging	Excellent	Poor	Excellent	Poor	Poor
Drawdown	Excellent	Poor	Poor	Poor	Poor
Benthic Barrier	Excellent	Poor	Excellent	Poor	Poor
Shading	Good	Good	Good	Good	Good
Nutrient inactivation	Experimental	Experimental	Experimental	Experimental	Experimental