Giant Salvinia Task Force

Salvinia Molesta
Status Report and **Action Plan**

Dr. Earl Chilton II
Colette Jacono
Dr. Michael Grodowitz
Charles Dugas

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Action Plan Sub-Committee Members (Reviewers)

Dr. Earl Chilton II, Texas Parks & Wildlife Department (Chair)
Charles Dugas, Louisiana Department of Wildlife and Fisheries
Larry Fowler, United States Department of Agriculture
Dr. Michael Grodowitz, United States Army Corps of Engineers
Dr. Jim Hyde, Sabine River Authority (Louisiana)
Colette Jacono, United States Geological Survey
George Nash, United States Department of Agriculture
Dr. Michael Smart, United States Army Corps of Engineers
Michael Stewart, United States Army Corps of Engineers
Jack Tatum, Sabine River Authority (Texas)

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Background and Distribution

Salvinia molesta, also known as giant salvinia and Kariba Weed, is a rapidly proliferating aquatic fern that has spread from its native habitat in southern Brazil to many other tropical countries around the world, as well as to Australia, New Guinea, New Zealand, South Africa and now to the United States (Mitchell 1979). It ranks second behind water hyacinth *Eichhornia crassipes* on the noxious aquatic weed list where it was placed in 1984 (Barrett 1989). It damages many aquatic ecosystems by overgrowing and replacing native plants that provide food and habitat for native animals and waterfowl. Additionally, salvinia blocks out sunlight, and decreases oxygen concentration to the detriment of fish and other aquatic species. When plant masses die, decomposition lowers dissolved oxygen still further. Blockage of waterways to commercial as well as recreational traffic is common.

In the U.S. giant salvinia has been found in 10 states including Alabama, Arizona, California, Florida, Hawaii, Georgia, Louisiana, Mississippi, North Carolina, and Texas. Additionally, giant salvinia was reported from a 1.5-acre pond in South Carolina in 1995. However, within a year the infestation had been eradicated, and there have been no further cases in that state. Although giant salvinia is found in at least nine public reservoirs, lakes, and rivers nationwide, the most serious infestations so far appear to be in Texas and California. In September 1998 giant salvinia was discovered by the Sabine River Authority (SRA) of Louisiana in Toledo Bend Reservoir, an 186,000-acre body of water that forms a large portion of the boundary between Texas and Louisiana. It was the first reported infestation in public water in the U.S. The plant is now widespread in the reservoir. Since 1998 the plant has spread to three other reservoirs in Texas including Lake Conroe, Sheldon Reservoir, and Lake Texana. Eradication efforts appear to have been effective in Lake Conroe and Sheldon Reservoir. Giant salvinia hasn't been found in either water body since Fall 2000. In August 1999 giant salvinia was discovered in Lower Colorado River at Imperial National Wildlife Refuge, bordering Arizona and California. The infestation as originated on the California side of the Colorado River, in the Palo Verde Irrigation District (PVID) drain, which flows into the Old Colorado River channel before entering the Colorado River. It was estimated that 1-2 million plants a day were floating down the PVID drain (Personal observation, Earl Chilton, 1999). Giant salvinia has been observed as far downstream as the Imperial Dam (USGS, 2001).

Plant quarantines are difficult to enforce with a plant that can reproduce from tiny buds and fragments. Giant salvinia may have been introduced intentionally as an aquarium or pond plant since it is small, attractive, and hardy, but it has also been recognized and destroyed as a contaminant in shipments of aquatic plants from Sri Lanka (Nelson 1984). It may also have been brought in as packing with fresh, iced fish. It has been widely sold and distributed by private nurseries in at least 11 states, as well as over the Internet. In Louisiana one nursery reported at least 400 cash sales (C. Dugas, pers. comm.), and in 1999 giant salvinia was sold illegally in at least 48 California cities (CDFA 1999).

Once established on a large lake or stream, the fact that it is free-floating provides for its rapid dispersal by wind and currents. Further spread to other lakes and streams may easily be accomplished on boating and fishing equipment, and perhaps even by waterfowl and other animals. Its appearance on Toledo Bend is especially odious news for other lake managers since the reservoir is frequented by thousands of fishermen who transport their equipment to many other areas including other states.

Morphology and Growth Characteristics

This fern bears little resemblance to common terrestrial ferns familiar to all. Typically, mature *Salvinia molesta* has paired, ovoid leaves 1"-1 1/2" long whose upper surfaces are covered with hairs, each terminating in a cage-like structure which serves as an air trap, rendering the leaves practically unwettable. The root mass, considered to be a modified third leaf, hangs underneath in the water as do the spore producing nodules (sporocarps) found as chains among the roots. A colony consists of numerous leaf pairs connected together by a branching rhizome which is easily broken, producing viable fragments. Dominant features of giant salvinia are its tremendous growth and reproductive rates; a single plant is said to be capable of multiplying to cover forty square miles in only three months (Creogh 1991-92). Individuals have a size doubling time of 2-4 days (Gaudet 1973, Mitchell 1979).

The colonizing or immature stage is characterized by smaller leaves (< 1") that lie flat upon the water. Large areas may become covered by this stage, which can easily be confused with *Salvinia minima*, itself a noxious weed of wide distribution in the southern U.S.A. As giant salvinia mats age and increase in size, crowding occurs, the leaves become larger and are pushed erect as they rapidly expand and compete for space. Thus mats are formed, and under the proper conditions may grow up to a meter thick, becoming nearly impenetrable by large boats (Thomas and Room 1986a).

Ferns (Pteridophyta) reproduce by means of spores, but *S. molesta* may be an exception to this rule. The species does produce spores, but they appear to be genetically defective. Its sole means of reproduction is probably vegetative, by fragmentation and the breaking away of dormant buds (Mitchell and Gopal 1991). It has been suggested, therefore, that the entire world population of giant salvinia may be a genetic clone (Barrett 1989, Nelson 1984, Werner 1988)

Preferred Habitat

Due to the fact that it is a free-floating plant, *S. molesta* grows best where the water is minimally influenced by wind and current. A high nutrient content (especially nitrate), as would be found in eutrophic waters, fertilized fields (rice fields) and waters polluted by wastes, is favorable to its growth. Moderate temperatures between 40 degrees and 90 degrees Fahrenheit are required (optimum 77-81 degrees Fahrenheit), but it is known to be able to survive severe winters (Room 1986, Room and Kerr 1983,Whiteman and Room 1991). Although the weed is highly adaptable, it typically does not colonize brackish or marine environments. However, it has been reported from tidally influenced streams in southeast Texas (Personal Communication, Gerard Sala, Sabine River Authority). Tropical zones are its native habitat, but it grows very well in climatic zones found within the United States (NPAG 1998).

Probable impacts in the United States

Agriculture

Giant salvinia is known to be an agricultural pest. In Java for example, it can reduce rice production by competing for water, nutrients, and space in cultivated areas (Oliver 1993). For example, in Texas rice ranks fifth among the states largest cash crops with an estimated economic impact of $1,000,000,000 annually. Even a very small reduction in rice production due to giant salvinia could cost the state many millions of dollars annually. The crawfish and catfish industries, of great importance in the central gulf area, should be equally susceptible. Large numbers of commercial and private fishing boats are dependent for transportation on bayou and canal systems that are usually polluted, again a perfect habitat for giant salvinia.

Water supply

Not only can giant salvinia clog waterways and obstruct the flow of water in rivers streams and canals, in warm climates it can greatly increase the amount of water lost to the atmosphere due to evaporation. Water lost to giant salvinia transpiration can be up to four times that of normal evaporation.

Recreation

Little deviation from the aforementioned pattern of environmental destruction is to be expected. The southern states could be especially hard hit because of their temperate climate. Sport fishing and hunting, economically important in many areas, could be severely curtailed. Waterfowl may lose access to the water, and water beneath salvinia mats would not be a healthy environment for fish. The water quality may be impaired for municipal and industrial supplies, and without treatment will be practically useless for aquaculture because of its ability to spread giant salvinia.

Many areas, in Louisiana and Texas around Toledo Bend Reservoir, which is the area of most urgent concern for preventing giant salvinia's spread, depend heavily on boating, fishing and tourist visitation for economic survival. Retirees are already complaining that giant salvinia is restricting them to their boathouses.

Areas with economies based on aquaculture and water transportation, such as parts of Malasia, Africa, Sri Lanka, New Guinea and the Philippines have suffered severe losses due to giant salvinia infestation, commercial and sport fishing, block waterfowl habitat, and destroy a water-based economy in a single growing season (Barrett 1989).

Navigation

Giant salvinia mats up to a meter thick can easily impede most boat traffic, including commercial vessels. In New Guinea thousands of local villagers that depended on riverine commerce for their livelihoods were forced to abandon the Sepik River when it became infested with giant salvinia. Typically, infestations on the order of several inches in thickness can inhibit recreational boating activity.

Property Values and Local Economies

Giant salvinia has the potential to cause drastic declines in lakeside or riverside property values. Over abundant aquatic vegetation such as hydrilla and water hyacinth commonly cause declines in property value, because the infestations are not aesthetically pleasing. When this happens the tax base may be very much impacted in small communities where the majority of individuals, or at least the majority of high price homes are on waterfront property.

Water Quality

Giant salvinia has been associated with reduced oxygen concentrations (Hattingh 1961).

Ecological health and biodiversity

Because of giant salvinia's high growth rate it is capable of out competing most other floating aquatic plants under the right conditions. In the laboratory giant salvinia populations have been observed to double about every other day, in the field doubling rates as high as once every 7-8 days have been observed. In some cases giant salvinia has even displaced water hyacinth, once considered the worlds worst aquatic weed. Giant salvinia can create a monoculture up to one meter deep crowding out all other floating plant species, and shading out submerged species. The thick monoculture causes low oxygen problems underneath the surface mat, so that a virtual desert is created underneath, devoid of all but the hardiest plant and animal life.

Threatened or Endangered Species

Often threatened or endangered species have a very limited distribution. Should giant salvinia invade the critical habitat of such a species exterpation can easily occur due to shading, crowding, or altered pH effects (in the case of plants), or low oxygen and altered pH (in the case of animals).

Human health animal health

In addition to its direct impact, giant salvinia provides habitat for snails that are intermediate hosts for *Schistosoma* sp. which parasitize the human intestinal and urinary tracts (Thomas and Rom 1986a). It is also an important host plant for *Mansoni* mosquitoes that serve as vectors for rural filariasis (Holm et al. 1977; Pancho and Soerjani 1978).

Giant salvinia mats also provide ideal habitat for mosquitos, and a breeding ground for West Nile Virus as well as encephalitis.

International treaties

A number of international treaties could potentially be affected by salvinia infestations in international water. For example, international agreements between the U.S. and Mexico, mediated by IBWC (International Boundary and Water Commission) have already been affected by severe aquatic plant infestations in the Rio Grande. Hydrilla and water hyacinth infestations are contributing to water loss and inhibiting the flow of needed water downstream. A tight water budget for the river has contributed to heightened tension between the two countries and stretching the water treaty almost to the limit. The addition of giant salvinia would only multiply the already significant problems faced by Mexican and U.S. officials.

Costs

Measures to stop or slow the expansion of *S. molesta* infestations in U.S. waters, and to lessen their impacts have associated costs and may generate their own impacts to water resources/uses that must be mediated. Costs are associated with a wide variety of management functions including:

Strategic Planning

Administration of Management Strategies and Regulations

- Plan development
- Monitoring
- NEPA requirements
- ESA requirements

State requirements

Implementation of Management Strategies

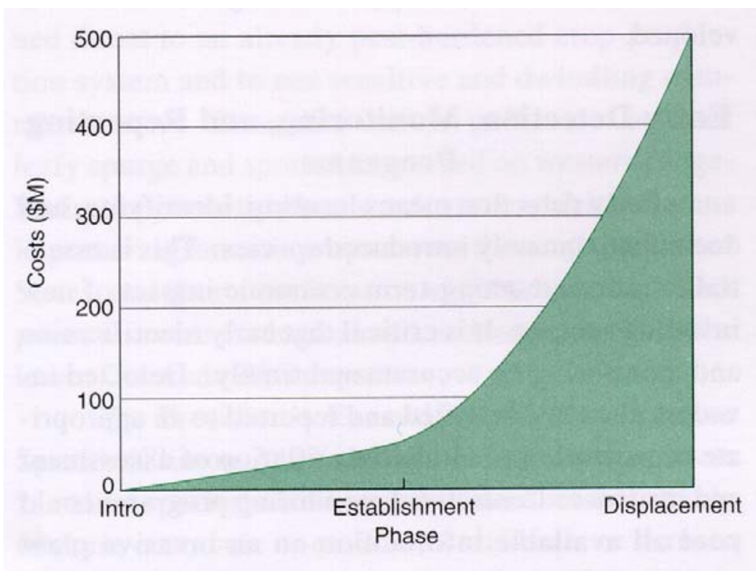
Biological control
Chemical control
Mechanical control
Physical control
Preventive measures

Lost Opportunities

Projects/actions either not started or delayed due to *S. molesta*

Costs associated with aquatic vegetation control often increase exponentially if there are delays in the implementation of control programs (Figure 1)

Figure 1. Management costs versus invasion phase relationship show that prevention is the least costly phase, with exponentially rising costs once the invading weed species have become established, and even higher costs if the invading plant is displacing native species and/or disrupting native habitats (From Mullin et al. 2000).



Management Options

I. No Action

Pros:

No Cost.

No personnel required.

Cons:

Continued spread of salvinia in Toledo Bend Reservoir, and elsewhere.

Development of problematic stands of salvinia.

Losses of native and naturalized vegetation.

Probable detrimental changes in fish community structure and abundance.

Decreased recreational opportunities in salvinia infested areas, including swimming, fishing, boating, skiing, etc., as well as concomitant local and state economic losses.

II. Physical Control

Physical control of free-floating aquatic plants such as giant salvinia is accomplished by use of methods that do one of the following: (1) directly remove the target plants from the waterbody, (2) cause *in situ* death of the target plant by inflicting sufficient physical damage (by chopping or shredding), (3) impede the free movement of the target plant within the waterbody, or (4) alter the infested waterbody in a manner that eliminates or reduces the extent of suitable habitat for problematic growth of the target plant. Generally, physical control methods are not among the preferred methods for large-scale control of free-floating plants (Madsen 1997; Wade 1990). This is due both to the "escapability" of free-floating plants (Culpepper and Decell 1978) and to the excessive biomass associated with these species (e.g. giant salvinia - up to 80 tonnes/hectare [~36 tons/acre]; Oliver, 1993).

The following is a listing of the expected Pros and Cons of each of these methods for control of giant salvinia. Also, examples are provided of the types of problem situations for which each of the physical control methods are directly applicable. Finally, an effort has been made to provide estimates of costs associated with applying these methods for giant salvinia in the southeastern U.S. It is recognized, however, that since physical control methods are generally not applied to large-scale, floating plant problems in the U.S., or in other countries with similar economies and water resources, comparable cases for deriving cost estimates for giant salvinia control with these methods are not available.

A. Direct Removal

There are essentially three methods for direct removal of free-floating plants from a water body. These are: (1) hand removal, (2) water-based mechanical removal, and (3) land-based mechanical removal. Most large-scale control programs for free-floating plants do not rely primarily on direct removal methods.

Hand Removal.

Use of large-scale hand removal methods is generally restricted to third world countries. There, the availability of a relatively inexpensive labor force, coupled with non-availability of other options, makes the use of physical control methods more commonplace. However, even under these situations, effective results in large-scale applications are rarely achieved.

Pros:

Can provide highly selective control.

Does not result in any water-use restrictions.

Cons:

Requires large labor force to implement on large-scale.

Limited to shallow water areas adjacent to shore.

Benthic habitat may be impacted by human activity.

Operations must be repeated often due to the growth characteristics of giant salvinia.

Applicability:

Limited in applicability to removal of isolated plants from areas adjacent to water front facilities (e.g. houses, marinas, boat launches). Even in areas adjacent to shore, not suitable for removing established infestations. However, may be only alternative in areas where other techniques cannot be used (e.g. potable water intakes inaccessible by mechanical equipment) and which cannot wait on insect biocontrols to be effective. Can possibly be most effective at boat launches for removing plants from boats during ingress or egress from a water body.

Cost:

Variable, depending on source of labor to conduct efforts and extent of vegetation to be removed. For well established giant salvinia infestations (36 tons/acre) control by hand removal may exceed $2000/hectare (Approximately $800/acre). For activities such as hand removal of attached plants at boat launches, expenses may be very low, possibly as incidental duty by attendant.

Mechanical Removal

(a) Water-based harvesting equipment. Primary reliance on large-scale mechanical control efforts is limited in the U.S. to submersed aquatic vegetation (SAV; e.g. Eurasian watermilfoil) control in the Midwest and Northeast. Control by these methods rarely used for free-floating plant species, including water hyacinth, waterlettuce, and common salvinia, in southeastern states (mainly due to successful maintenance control through integrated use of EPA approved aquatic herbicides and insect biocontrol agents). Consider the following when evaluating the use of water-based harvesting equipment.

Pros:

Provides direct removal of plants from specific treatment areas only.

Because salvinia biomass is physically removed from the system, some water quality concerns (increased nutrients and decreased dissolved oxygen) associated with use of effective, fast-acting contact herbicides are eliminated.

Avoids unique water-use restrictions (e.g. waiting period for use for irrigation purposes) imposed by application of EPA approved aquatic herbicides.

Provides some level of selectivity (at least spatially).

Cons:

Harvested plant material has to be disposed of.

Due to their size and propulsion systems, these systems typically cannot access shallow areas (< 0.75 meters).

Due to their method of action, these systems cannot operate in areas with numerous obstructions near the water surface (e.g. logs, stumps, rocks, piers, etc.).

Very difficult to accomplish removal of free-floating plants (stage 1 and 2) in "open" systems; therefore addition of some type of floating boom system may be required to collect plants prior to mechanical removal, or to restrain plant movement during the removal operation (Cullpepper and Decell 1979; also see below).

Due to tremendous fresh weight of stage 3 plants in well established infestations (up to 80 tonnes/hectare) (Oliver 1993), harvesting rates by conventional harvesting systems may be too slow to be effective. Rates could be increased if onboard storage capacity for harvested material were increased (see Appendix 1).

Operational productivity of mechanical removal systems greatly reduced if treatment site is distant to boat launch or alternate water access site.

In order to accomplish the goal of plant removal, water-based equipment may have to be supported by land-based equipment for off-loading harvested plant material directly onto shore for disposal, or onto trucks for transport to remote disposal sites.

Often slow and costly to move to new shore takeout point or waterbody, making treatment of widely dispersed infestations with same equipment difficult.

Operations must be repeated often due to the growth characteristics of giant salvinia.

Applicability:

Infestations in moderately deep, obstruction-free areas within a few kilometers of shore access sites (to limit overwater transport time). Also, in other locations requiring control that are not suitable for herbicide applications, or that require control in timeframe shorter than biocontrols can provide results. May be used in association with floating barriers (see following section), or in areas that naturally trap floating vegetation (e.g. embayments exposed to large fetch, water control structures, bridges/causeways).

Cost:

Purchase: Conventional harvesting system
~ $60,000 to $200,000 each (depending on size and support equipment)

Per Area Treated (by "contracted" harvesting operation)
$1000 to $2000/hectare ($400 to $800/acre)

(b) Land-based Removal Equipment. Several types of heavy-lifting equipment (e.g. draglines, hydraulic cranes, conveyors) can be used to remove floating plants from watercourses. Though they are occasionally used to remove heavy growths of floating plants from completely obstructed canals or similary narrow waterways, they are rarely used to remove free-floating plants which typically are difficult to contain with semi-stationary equipment. In the Sacramento Delta system, however, water hyacinth was historically removed from the water course at a Bureau of Reclamation (BOR) water intake structure by the use of a "fixed-place" conveyor system. Essentially, free-floating plants were directed to the conveyor system by currents and booms. The conveyor, which was operated on an as-needed-basis, projected into the waterway and removed the water hyacinth from the water and lifted them onto the bed of an awaiting truck. .

Pros:

Can access certain infestations inaccessible by floating equipment

Accomplishes removal of plant biomass from treated area

No water use restrictions imposed by application

Cons:

Harvested plant material has to be disposed of

Limited to infestations adjacent to shore access sites

Extremely costly

Repeated removal operations will be necessary

Applicability:

Limited to plant removal from sites that are directly accessible by the shore-based equipment. Includes narrow channels with good access on both sides, and to other accessible sites where plants might collect. Pusher boats or currents may be used to relocate plants to confined areas accessible by these systems.

Costs:

Difficult to estimate, but typically regarded as very expensive. The BOR water hyacinth conveyor system had an annual operating budget of several hundred thousand dollars, prior to initiation of herbicide applications around 1983 (Anderson 1990). This is especially significant when one considers that the total water hyacinth infestation in the Sacramento Delta waterways was only around 200 hectares, and this expense was incurred simply by maintaining the intakes at this single pumping station. The bulk of the infestation was not treated by this method.

B. ***In situ* Choppers/Shredders**

New Equipment. Over the past few years, some innovative mechanical control systems that control plants by inflicting physical damage *in situ* have been developed. One such system, the Terminator (Master Dredging Co.), has been demonstrated for use against water hyacinth in Florida and Texas. Another comparable system (Chop & Drop, Inc.) has also been used in Florida.

Pros:

Can be used to open channels through otherwise impenetrable infestations.

Can provide spatial selectivity.

Does not require removal of plant biomass.

Does not impose water use restrictions.

Cons:

Does not provide removal of plant biomass, which will decay and possibly create water quality problems.

May kill associated organisms (fish, mammals, reptiles, invertebrates) that cannot escape "action" of the equipment.

Will most likely help spread giant salvinia by fragmentation.

Applicability:

For demonstration purposes only at this time. To open lanes for boat access and other purposes through dense infestations of giant salvinia and other noxious plants.

Costs:

~ $400/hour for demonstrations (USAE Jacksonville District. Personal communication). (Note: Extrapolates to ~$100,000 for 6-week demo)

C. Barriers to Free Movement

Floating booms

The use of floating booms can provide numerous worthwhile functions in a floating plant eradication program. They can be deployed to prevent floating plants from entering into, and thereby clogging, water intakes, marinas, swimming areas, or other susceptible sites. Booms can also be used to collect or contain plants in an otherwise open setting. Booms placed around a boat launch may serve two useful purposes: (a) preventing plants from a heavily infested water body from interfering with ingress or egress at boat launches, and (b) preventing plants that have been accidentally introduced at the boat launch from escaping into the open water body. Floating booms can also be used to collect those floating plants being moved by currents within the main course of the water body, as well as those entering the main course of the reservoir from feeder embayments. Plants collected in such manner are more efficiently treated with other control methods.

Pros:

After deployment, operation of booms fairly passive.

Can achieve fairly high level of site specific control.

Low technology, fairly inexpensive.

Little off-target impacts.

No water use restrictions.

Can play major role in preventing new infestations.

Cons:

Does not provide "active" control of existing infestations.

Effectiveness limited spatially, except when considered as a preventive measure.

Easily vandalized

Applicability:

Mainly for protection to fixed structures and facilities. Also for containing infestations for treatment by other methods, and for helping prevent new introductions.

Costs:

Not available, but fairly inexpensive.

Other physical barriers

Physical barriers of various other designs can be included in a Giant salvinia control program.

Pros:

Provide a dependable means of preventing plants from entering or escaping.

Cons:

Require continual upkeep and maintenance.

Applicability:

Gratings can be used to prevent plants from entering various water intakes (e.g. pumps, , or from passing over or through water control structures to infest new waterways.

Costs:

Variable.

D. Habitat alteration

Drawdown.

The purpose of drawdowns in Giant salvinia control programs is to strand the plants on the shoreline for sufficient period to cause mortality by dessication or freezing.

Pros:

Can provide large-scale control if water levels can be adjusted.

Can provide selective control if possible to "time" with phenology of sensitive species.

If permitted by operational requirements of the water body, relatively inexpensive.

Cons:

May have significant detrimental impacts to ecosystem.

May significantly impact secondary uses of the water body (e.g. boat access).

Since salvinia is a floating plant many viable individuals will remain on the water.

Applicability:

Except for natural occurrences, use of drawdown limited to water bodies with water control structures.

Costs:

Variable, but typically inexpensive where applicable.

III. Chemical Control

Research concerning the effectiveness of herbicides on giant salvinia (*Salvinia molesta*) in the United States has been lacking. However, there has been some work concerning the efficacy of the herbicides 2,4-D, diquat, endothall and glyphosate on common salvinia (*S. minima*). In addition, some applications were made using fluridone, diquat and glyphosate on giant salvinia in New Zealand, New Guinea, Malaysia and Australia.

Thayer and Haller (1985) reported diquat, endothall, and glyphosate to be equally effective on common salvinia (80-90 % control). 2,4-D was not effective. Glyphosate and fluridone were reported to be ineffective in controlling giant salvinia in New Guinea and New Zealand (Mitchell, 1979 and Wells et al. 1979). Diquat, at 4.5 kg/ha, effectively controlled giant salvinia in Malaysia (Kam-Wing and Furtado 1977). Hyde (personal communication 1998) reported that fluridone (at about 20 parts per billion) applied in an 0.5 acre isolated area of Toledo Bend was showing good results until the lake waters rose and diluted the herbicide in the area of the application. A mixture of 3% diquat (Reward) and 5% double chelated copper (Nautique) applied in another area of Toledo Bend was reported to be very effective (Temple, personal communication). A giant salvinia infestation in a two-acre lake in South Carolina was eradicated with applications of diquat (Reward) and fluridone (Sonar). First, two treatments of Reward at a rate of 0.75 gallons/acre were made to kill most of the matted vegetation. Then the entire lake was treated with Sonar at a rate of 1.3 quarts/acre to eradicate the remaining plants (de Kozlowski, personal communication 1998).

Research is being conducted at Louisiana State University on the effectiveness of four herbicides in controlling various aquatic plants. These are imazapyr (Arsenal), triclopyr (Garlon), glufosinate (Finale), and bensulfuron (Londax). No work has been done with giant salvinia; however, the study could be expanded to include this plant. If any of these herbicides were shown to be effective, an aquatic label would have to be obtained before they could be used on aquatic plants.

Sonar®

Active ingredient: Fluridone (1-methyl-3-phenyl-5-[3-(trifluoromethyl)phenyl]-4(1H)-pyridinone)

Pros:

Sonar may be used at low concentration levels.

Sonar may be used as a broadcast treatment. Since it is in the water it may be effective even on plants not observed by the applicator.

Low dissolved oxygen usually not a problem.

Cons:

Requires very long contact time, in some cases the treatment may be spread out over several weeks to provide the necessary contact time (under normal treatment conditions in still water).

Takes up to 100 days for full results.

Cannot be used within ¼ mile of a potable water intake.

Treated water should not be used for irrigation for many days.

Efficacy in giant salvinia seems to be variable.

In flowing water special slow release herbicide delivery equipment would be required. The cost per unit ranges from $17,000 to $20,000.

Applicability:

Little applicability in flowing water using conventional delivery systems. However, experimental drip delivery systems, which expose target plants to low herbicide concentrations over an extended period of time, have shown promise.

Cost:

~$700-1,400/acre (depending on depth) herbicide only, (~$927/acre labor and equipment included, at $823/acre chemical)

Aquathol®

Active ingredient: Dipotassium salt of endothall (7-oxabicyclo [2,2,1] heptane-2,3-dicarboxylic acid

Pros:

Requires very short contact time (~2 hrs) with target plant (under normal treatment conditions in still water).

Very quick acting, results in 7-10 days.

Remains in the water column only a matter of minutes.

Cons:

Efficacy on giant salvinia is unclear, although there is evidence that it does very well against common salvinia *Salvinia minima* at treatment rates of 5 gal/acre.

Low dissolved oxygen can be a problem if large areas are controlled at once.

Water from treated areas cannot be used for livestock, or as a municipal water source for 7 days after application.

Problems with interpretation of the label must be worked out with State Departments of Agriculture, and U.S. Environmental Protection Agency.

Target plants may recover and grow back.

May have to be used more than once per growing season.

In flowing water, special slow release herbicide delivery equipment may be required. The cost ranges from $17,000 to $20,000/unit.

Applicability:

Can be used in moderate flow situations where immediate use of the water for drinking or livestock is unnecessary. As with fluridone experimental drip delivery systems which expose target plants to low concentrations over extended periods of time have shown promise.

Cost:

$400-$600/acre (herbicide only)
(~$584/acre labor and equipment included, at $480/acre chemical)

Weedar 64®

Active ingredient: 2,4-D (2,4-dichlorophenoxy acetic acid, dimethylamine salt)

Pros:

Requires short contact time with target plant.

Very quick acting, results evident in a few days.

Sprayed on floating plants and so very little enters water column.

Cons:

Salvinia is not currently on the Weedar 64 label. Therefore, label change would be required to use 2,4-D on giant salvinia.

Reportedly, 2,4-D is ineffective on salvinia at legal application rates.

Low dissolved oxygen can be a problem if large areas are controlled at once.

Treated water cannot be used for livestock, or as municipal water source for 21 days after application, or until such time as an approved assay shows that the water contains no more than 0.1 ppm 2,4-D acid.

Problems with interpretation of the label must be worked out with Texas Department of Agriculture, and U.S. Environmental Protection Agency.

Plant recovers and grows back quickly.

May have to be used more than once per growing season.

Applicability:

Can be used on floating plants regardless of whether or not they are on flowing water.

Cost:

$12-$15/acre, $60-$75/river mile (~$142/acre labor and equipment included, at $12/acre chemical).

Reward®

Active ingredient: Diquat (6,7-dihyrodipyrido (1,2-🏆:2’,1’-c) pyrazinediium bromide)

Pros:

Reportedly, diquat may be the most effective legal contact herbicide available for control of giant salvinia.

Requires short contact time with target plant (minutes).

Very quick acting, results evident in a few days (usually less than 7 days, and in some cases the same day).

Sprayed on floating plants and very little enters the water column.

Cons:

Low dissolved oxygen can be a problem if large areas are controlled at once.

Treated water cannot be used for livestock, or as public water source for 0-5 days after application depending on application rate and how the water will be used.

Surviving plants may re-establish population levels within weeks.

May have to be used more than once per growing season.

Water used to mix Reward must be clean, turbid water may deactivate diquat.

Applicability:

Can be used on floating plants regardless of whether or not they are on flowing water.

Cost:

~$75/acre, ~$75/shoreline mile (~$173/acre labor and equipment included, at $75/acre chemical)

Rodeo®

Active ingredient: Glyphosate (N-(phosphonomethyl) glycine)

Pros:

Requires short contact time with target plant (hours).

Very quick acting, results evident in about a week.

Glyphosate has proven to be very efficacious for giant salvinia control in some situations (e.g. Lake Conroe, Texas).

Sprayed on floating plants and so very little enters water column.

Cons:

Efficacy on giant salvinia is in some doubt based on published literature.

Low dissolved oxygen can be a problem if large areas are controlled at once.

Extremely clean water needed for mixing if large mats are treated.

Plant recovers and grows back quickly.

May have to be used more than once per growing season.

Cannot be used within 0.81 km of a potable water intake.

Salvinia not currently on the Rodeo label

Applicability:

Can be used on floating plants regardless of whether or not they are on flowing water.

Cost:

~$75/acre, $375/river mile (~$205/acre labor and equipment included, at $75/acre chemical).

Chelated Copper (Cutrine-Plus®, Komeen®, K-Tea®, , Algae Pro®, etc.)

Active ingredient: Copper chelates

Pros:

Requires short contact time with target plant (~3.0 hours in running water (under normal treatment conditions in still water).

Very quick acting, results evident in a few days.

No use restrictions.

May be effective on salvinia when used in conjunction with diquat.

Cons:

Low dissolved oxygen can be a problem if large areas are controlled at once.

Plant may recover and grow back quickly.

May have to be used more than once per growing season.

In flowing water special slow release herbicide delivery equipment would be required. The cost ranges from $17,000 to $20,000/unit.

Applicability:

Can be used on salvinia, even if plants are in flowing Water.

Cost:

$128-$300/acre (assuming 5 ft. average depth).

IV. Biological Control

Simply stated, biological control is a management technology that uses a control organism to suppress, control, or eradicate a target organism (almost invariably exotic). In order to lessen ecological impacts host-specific control organisms are preferred, but less specific organisms are sometimes used. Over the years biological control has been used with success on a variety of plant species. These are typically non-indigenous species without the usual complex of insect herbivores and plant pathogens that keep native biota at realistic levels. Successful examples of biological control for plant suppression include several species of thistles, leafy spurge, knapweed. In the aquatic/wetland arena biological control success stories include alligatorweed and waterlettuce. It is important to note that in the most successful cases the introduced agents are highly host-specific.

The process of obtaining and eventually releasing host-specific biological control agents may be lengthy. Steps involved include: 1) initial overseas surveys and exploration to identify potential agents, 2) overseas testing and research of the discovered organisms, 3) host-specificity testing under rigorous quarantine conditions to determine suitability and safety for release in the U.S., 4) a release and establishment period with long-term insect/plant population monitoring, and finally, 5) transfer of the information on the use of the agent to operational and resource management personnel. This process can take anywhere from 5 to 20 years before a suitable organism is identified, tested, released, and eventually deemed effective. The requirement of such a long-term investment in time, manpower, and money is probably one of the biggest drawbacks to the use of biological control for the management of a wider variety and number of plant species.

While chemical control has been used with some success for *Salvinia molesta* management, biological control techniques are becoming accepted worldwide as an alternative method. With the discovery and release of the salvinia weevil *Cyrtobagous salviniae* dramatic and often complete control of *S. molesta* was achieved in a matter of months in many areas of subtropical and tropical Australia, Papua New Guinea, and Namibia. The use of this insect species is now the leading long-term method of control in all areas of the world with major *S. molesta* infestations.

C. salviniae is a small weevil ranging in length from 1.5 to 2.0 mm. It is essentially black but newly emerged individuals are often brown. Legs are reddish-brown in coloration. The dorsal surface of the weevil is covered with numerous shallow depressions or punctures as well as yellow peltate scales. Adults typically reside on or beneath the leaves or fronds of *S. molesta*. A thin film of air adheres to the bottom of the weevil allowing for respiration during periods of submergence. Eggs are laid singly in cavities in the plant formed by female feeding activity. Eggs hatch in approximately 10 days. The larvae are white and attain lengths of only 3 mm. Total larval development requires 3 to 4 weeks. Larvae construct cocoons on the "roots" (in reality submersed leaves). The pre-pupal and pupal periods last about 2 weeks.

Adults will feed on the leaves leaving small irregularly shaped holes but prefer feeding on newly formed leaf buds. Larvae feed within the roots, rhizomes, and leaf buds. Combined feeding action can be devastating with reported impact to field populations observed in just several months instead of years as typically seen with other biological control agents.

Cyrtobagous salviniae

C. salviniae has recently been approved for release and evaluation in Texas and Louisiana, and promises to be one of the most effective control technologies available for the management of *S. molesta* based on its reported efficacy in other areas of the world. However, below please find both pros and cons to its use in the U.S.

Pros:

Highly effective

In tropical areas, effect time is measured in terms of months instead of years (as with many other insect biological control agents).

It is highly cost effective since the impact is realized for years without re-introduction and the process of locating and testing the agent, which can effectively raise the price tremendously, can be circumvented since *C. salviniae* is already in the country and host-specificity is well documented.

Cons:

Longer effect times are observed in cooler subtropical or warm temperate areas and could potentially be on the order of years.

In general, biological controls tend to reduce or suppress, not eradicate, plant populations.

The use of *C. salviniae* is not an exact control methodology in that it's effectiveness may vary depending on climatic conditions such as temperature, plant nutritional status, and other abiotic and biotic conditions.

Applicability:

C. salviniae can be used in areas where plant populations are large.

Costs:

Currently, the USDA is spending a total of about $100,000.00 per year on *C. salviniae* introduction and evaluation in Texas and Louisiana.

Triploid grass carp *Ctenopharyngodon idella*

Grass carp, or white amur, are plant-eating fish native to Asia. They are capable of surviving at temperatures ranging from below freezing to over 100ºF. Grass carp grow rapidly. In their native habitat they may typically grow 80-100 pounds. Fingerlings, juveniles and adults feed almost exclusively on plant material. Depending on temperature, water quality, and plant quality they may eat up to three times their body weight per day. Typically, submerged plants such as hydrilla are preferred food items, whereas floating plants (with the exception of duckweed) are among the last species consumed, however, there is some anecdotal information that grass carp may control giant salvinia. In general, recommended stocking rates are 5-10 fish per acre of waterbody.

Pros:

No chemicals introduced into the water and no effect on drinking water.

Usually long-term control
Plant biomass can be removed from the system.

Triploid grass carp will not reproduce.

Cons:

Although anecdotal information suggests grass carp successfully control giant salvinia, definitive scientific evidence in as yet unavailable.

If not confined, grass carp will typically leave target treatment area. In some cases they have been found over 200 miles from target treatment areas.

Grass carp may consume non-target plant species when available.

Grass carp may consume vegetation in non-target areas.

Grass carp are not readily susceptible to conventional capture techniques and are not easily removed from water bodies if overstocked.

Grass carp have been captured in brackish water up to 17 ppt (~50% sea water) and can even survive for short periods of time in hypersaline water. Therefore, escapees may be capable of feeding in some estuary situations.

Applicability: Waterbodies where confinement is possible and potential elimination of all aquatic vegetation is preferable to the nuisance plant infestation.

Cost: ~$50-300/acre (stocking rates for giant salvinia are undetermined. This estimate is based on experience with other plant species.)

Recommendations

The recommendation of the Salvinia Task Force calls for the eradication of *Salvinia molesta*, if possible, from all U.S. waters where it is currently found. A balanced, integrated approach utilizing all efficacious control methods available, including herbicides, physical containment, biological control organisms, and public education will be necessary to control the spread of salvinia. These recommendations are listed below.

1) Rapid Response

Each state should delegate responsibility for aquatic vegetation control to a single agency and charge that agency with developing a management and control plan for dealing with plants such as giant salvinia. The responsible agency should set up and advisory task force made up of state and federal agencies as well as various diverse interest groups to aid in the development of the plan (e.g. Departments of Environmental quality, Water Quality Control Board, Natural Resource agencies, River Authorities, Water management districts, Health services, Army Corp, Fish and Wildlife, EPA, etc.). The plan should not be implemented without the approval of other state resource agencies that deal with various aspects of the problem. If necessary an science advisory panel could be convened to provide input from national as well as local experts. The plan should provide:

1. Guidance relative to establishing positive, confirmed identification of giant salvinia.

2. Programmatic means of determining the extent of any infestation, the source of the infestation, possible resource needs, and possible regulatory needs, as well as ownership of sites, etc.

3. Rapid response alternatives

4. A monitoring plan to evaluate the effects/impacts of plan implementation.

5. A system for reviewing and modifying the plan if necessary.

2) Ongoing Eradication and Control measures

Herbicide: Two characteristics of *Salvinia molesta* make it resistant to herbicides and freezing; (1) buds and stems are below the water surface, (2) the leaves are virtually unwettable due to air trapped in the specialized hairs that cover their upper surface, and (3) the thick mats protect plants embedded within it. Therefore, if the chemical option is explored ample amounts of surfactant will have to be used in order to penetrate the leaf hairs.

Salvinia is susceptible in varying degree to common herbicides such as 2,4-D, hexazinone, diquat, paraquat (cannot be used in aquatic systems in the U.S.), ametryne and fluridone (Hyde and Temple 1998, Miller 1979, Thomas and Room 1986a). A recently developed double chelated copper herbicide (Nautique) used with Reward (disquat) has been very effective on thinly matted infestations at Toledo Bend Reservoir (Hyde and Temple 1998).

A nonconventional herbicide, developed in Australia, AF101, has been applied with considerable success (Thomas and Room 1986a). It combines the herbicide diuron with a surfactant in a solvent of acetone and kerosene. The mixture spreads on water as a thin film, wetting leaf hairs thereby destroying the fern's buoyancy. The diuron then acts on submerged terminal and axillary buds which would escape the surface treatment. In the U.S., however, diuron has no aquatic label, and the use of acetone and kerosene in public drinking water would generate significant resistance by resource managers and environmentalists alike.

The systemic herbicide, fluridone, has shown promise in a trial on Toledo Bend Reservoir, even though it was considered ineffective in tests in New Zealand (Hyde and Temple 1998,Wells et al. 1986). Again however, matted leaves protected from sunlight may be resistant to its action. Fluridone is not suitable for spot treatment, and fluridone treatment of the entire Toledo Bend Reservoir is not economically feasible.

There is little experience with herbicide use on giant salvinia in this country, thus further experimentation is essential. A "fair degree" of kill has been reported by a resident on Toledo Bend Reservoir, who merely sprayed a young mat of the fern with salt water of unknown concentration (Anonymous Toledo Bend Resident). However, given the large areas involved, and hence the large amount necessary to achieve significant results, salt may be more environmentally toxic than herbicides which will break down relatively quickly.

Mechanical methods of management have seen limited use, but the extreme growth rate along with the weight of the matted plant make these options very expensive and labor intensive. Floating booms and nets may be useful in isolating certain areas, but pressure from windblown mats has been known to break 3-inch steel cables and rip their anchors out of the banks (Thomas and Room 1986a).

Since giant salvinia requires nutrient rich water, careful attention to cleaning up polluted lakes and streams must be considered.

Biological control will probably be central to any plan for eradication of the plant. *Cyrtobaqous salviniae*, the salvinia weevil, has achieved great success in some parts of the world, such as on the Sepik River in New Guinea (Thomas and Room 1986b), and in South Africa (Cilliers 1991). It should be noted that the weevil does not completely kill off the host salvinia, but its use may still be a key step in combination with other treatments for eradication. The weevil has already been introduced to the United States (Florida) and since all evidence indicates that it is totally specific for *Salvinia* sp., there should be little problem in bringing it into other states (Room 1990, Sands and Schotz 1984).

Considering the limited and conflicting reports from various parts of the world, a number of environmental or other factors play a role in the effectiveness of herbicides on giant salvinia. It would appear that, in the United States, fluridone, diquat or a diquat/copper mix would be the herbicides of choice. Fluridone would have to be confined to areas with static water regimes, whereas, diquat or diquat/copper could be used in most situations. Experiences in Florida would suggest diquat as the herbicide of choice.

Approximate costs for herbicide using **either** glyphosate **or** diquat.

Herbicide	Glyphosate	Diquat
Texas (600 acres)	$ 27,000	$ 42,750
Louisiana (300 acres)	$ 13,500	$ 21,375
California (100 acres)	$ 4,500	$ 7,125
Other states (50 acres)	$ 2,250	$ 3,563
Surfactant (combined 1,050 acres)	$ 11,393	$ 11,393
	$ 58,643	**$ 86,206**
Salaries, Fringe, per diem, etc	$ 90,720	$ 90,720
Total (excluding equipment)	**$ 149,363**	**$ 176,926**

3) Research

Biological Control: Now that permits have been obtained for the release of *C. salviniae* in Texas and Louisiana, weevils have been released at selected locations and studies are underway with the following objectives:

Objective 1: Determine survival of salvinia weevils.

Since *C. salviniae* has not been used before in North America its survival is somewhat unclear foe several reasons. First, can it survive North American winters? Second, can it survive in the presence of such voracious predators as fire ants?

Objective 2: Determine sustainability.

Since Florida *C. salviniae* have fed only on the closely related plant species *S. minima* it is necessary to evaluate its development and effectiveness on U.S. populations of *S. molesta*. Toward this goal, Florida collected *C. salviniae* will be reared on *S. minima* and *S. molesta* and developmental success and time, as well as survival and effectiveness will be determined. These will be small-scale experiments performed under greenhouse/laboratory conditions. Based on the outcome of these experiments field release of U.S. *C. salviniae* will be determined. If continual feeding by U.S. collected *C. salviniae* on *S. minima* has caused genetic changes which limit its effectiveness on *S. molesta* then steps will be taken to obtain Australian *C. salviniae* which would entail reassessing the federal and state permitting process. Another, probably more prudent method is to test both Australian and U.S. strains of *C. salviniae* in Australia. This would be relatively easy to accomplish by Australian scientists since *C. salviniae* is already released in many areas of Australia and the scientists have much experience dealing with this agent.

Objective 3

Field release of small numbers of *C. salviniae* will be made in selected areas to determine establishment success and effectiveness. Insects will be collected from field locations in Florida and/or obtained from greenhouse rearing operations. These will be released at field locations and subsequently monitored for establishment and effectiveness.

Objective 4

Once insects are released populations will be monitored periodically for establishment and effectiveness. Since well established procedures have been developed in Australia for determining establishment and effectiveness, these procedures will be used and modified as necessary. Once establishment and effectiveness are confirmed plans will be made to initiate large-scale field collection/rearing and subsequent field release.

Objective 5

Concurrent with most of objective 5 will be the development of procedures for releasing large numbers of *C. salviniae*. This may entail moving individuals from existing populations of *C. salviniae* or developing large-scale mass-rearing procedures. Most likely a combination of both methods will be most effective. In addition, it will be necessary to implement monitoring procedures during this phase to quantify establishment, population increases, and subsequent impact. Also, since the use of biological control will be used concurrent with other methods of control, strategies that minimize impact to the biological control efforts will have to be designed and implemented.

Texas (Federal)	$ 50,000
Texas (State)	$ 14,000
Louisiana (Federal)	$ 50,000
Louisiana (State)	$ 14,000
Total	**$ 128,000**

Physical Barriers: Although physical barriers, such as booms, are not generally considered the most effective means of control of large infestations, there may be some applicability on a limited basis in coves, etc. of Toledo Bend. Additionally, giant salvinia has been found in at least six other locations in Texas. In situations where the infestation is small barriers may be an effective aid in preventing the spread of salvinia.

Estimated cost of Barriers	$ 40,000
Labor	$ 10,000
Total	**$ 50,000**

4) Prevention and Early Detection

Prevention and early detection should be a major part of any effort to control giant salvinia. Given the species rapid growth rate, preventing an infestation is obviously the most economical way of accomplishing control. In the event an infestation does occur it is vital to detect it early before management costs spiral out of control.

Regulations:

The first line of defense against infestation includes state, and federal regulations against importation, movement, sale, or possession of noxious weeds. These include:

The Plant Protection Act – The Plant Protection Act authorizes the Secretary of Agriculture (USDA) to regulate the import, entry, export, or movement in interstate commerce of any plant pest, unless the import, entry, export, or movement is authorized under a permit and is in accordance with such regulations as the Secretary may issue to prevent the introduction of plant pests into the United States or the dissemination of plant pests within the United States.

Federal Noxious weed list (enforced by USDA) – Lists the plant species that are regulated under the Plant Protection Act.

The Lacey Act - The Lacey Act prohibits "the importation into the United States, any territory of the United States, the District of Columbia, the Commonwealth of Puerto Rico, or any possession of the United States, or any shipment between the continental United States, the District of Columbia, Hawaii, the Commonwealth of Puerto Rico, or any possession of the United States, of the mongoose of the species *Herpestes auropunctatus*; of the species of so-called "flying foxes" or fruit bats of the genus *Pteropus*; and such other species of wild mammals, wild birds, fish (including mollusks and crustacea), amphibians, reptiles, or the offspring or eggs of any of the foregoing which the Secretary of the Interior may prescribe by regulation to be injurious to human beings, to the interests of agriculture, horticulture, forestry, or to wildlife or the wildlife resources of the United States, is hereby prohibited."

State prohibited lists (not all states have prohibited lists, but in general southern states, as well as California and Arizona do) – Lists may prohibit the importation, sale, purchase, or possession of a species or any part or propagule of a species deemed harmful by the state.

Prevention: Once the statutory framework has been laid for preventing the import of giant salvinia, State and Federal authorities should determine and track possible sources of infestation, both accidental and intentional. Experience has demonstrated that there is a market for giant salvinia. It has been sold in California, Louisiana, and Texas at numerous locations. Businesses that are particularly at risk of unintentional importation of salvinia transported accidentally along with fish or other aquatic biota include those associated with: 1) the aquarium industry, 2) horticulture, 3) commercial nursery industry, 4) specialty/ethnic food industry, 5) botanical gardens, 6) aquas coping catalogues, 7) pet stores, 8) individuals via internet, and 9) clubs. As possible sources of giant salvinia are identified within a state the following steps should occur:

1) USDA inspectors must be notified and shipments of aquatic material inspected at they enter the U.S. Effort must be made to increase the budget for these inspections.

2) State agencies that are responsible for enforcing exotic species regulations should be notified of possible violations, and equipped with budgets sufficient to fund state inspectors and enforcement personnel. In general, state Department of Agriculture, or state natural resource agencies are responsible for enforcing these regulations.

3) State Agriculture or natural resources agencies should outline disposal mechanisms.

4) Public Information/Awareness must be promoted by local, state and federal governments.

5) Research should be funded and directed toward defining the link between Nutrient influx and over abundance of aquatic vegetation.curring can it be corrected?

6) Resource and agriculture agencies, both state and federal should develop programs and mechanisms for alleviating nutrient influx problems.

Early Detection:

Early detection of giant salvinia infestations is vital if they are to be found and arrested while still in the introduction or establishment phases of growth when management or eradication costs are relatively low. In order to accomplish this task the following steps should be considered:

1) States should develop monitoring programs for aquatic exotic species, including giant salvinia, that are conducted on a regular basis by resource agencies.

2) Resource professionals (individuals working on the water) must be able to identify *S. molesta* and be on the look out for it.

3) Commercial pesticide applicators should be encouraged to contact state resource agencies if giant salvinia is found.

3) County agricultural agents should be well informed, especially since they visit and work with private landowners.

4) A monetary reward for public reports of new infestations may be considered. This would have to have defined guidelines to prevent someone from actually spreading the plant, reporting it and then collecting a reward.

5) Anglers, boaters, skiers, and other aquatic recreation enthusiasts should be educated relative to identification of giant salvinia, and who to contact incase it is sighted. Educational avenues may include public presentations by resource professionals (including poster presentations), development of a flyer to be placed in boater registration annual mail-outs, information placed in each states fish/game law booklet.

6) Efforts should be made to inform and encourage homeowner and marina associations to report sightings of giant salvinia in the area. Information packets and/or fact sheets should be developed.

7) Continue to distribute the original USGS fact sheet. Fact sheets can be modified to fit the needs of each state.

8) All available media sources should be utilized, including radio, television, magazines, journals, newspapers, newsletters, and internet sites.

9) Develop a recognizable "standardized" sign for boat ramps or other access points to alert recreationists to exotic species concerns on any given water body. A durable sign with photo of GS would be desirable.

10) Conduct spot inspections at public boat ramps located at infested lakes in California, Louisiana, and Texas, includes 6 full time technicians (seasonal student volunteer program may be implemented). **$172,500**

5) Public Awareness

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federal governments.

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Suggested projects:

- Production of 30 sec, 4 min and 10 minute videos for commercial television, public television, government agencies and public associations: Production cost $23,000

  Film cost for sub-masters, appropriate for television broadcast (will target news programs, county extension shows, gardening, fishing and outdoor shows) $25 each X 200 copies = $5800

  Film cost for VHS quality dubs appropriate for training and meetings (target government agencies, extension agents, schools, grower's associations, plant societies, garden clubs, sporting, fishing and boating clubs, etc: $3 X 350 copies = $1200

  Cost for buying and preparing mailing lists, mailing boxes, postage and return postage for each video: 550 X $5 = $3200

  Labor for packaging and mailing videos: $600

  Total for videos. **$33,800**

- Prepare and duplicate high quality information packets that include professional photographs, slides, bumper stickers, question and answer fact sheets for media writers and educators. Costs include preparation of mailing list and postage for local and national distribution and labor for packaging and mailing. $14,000

- Design and coordinate education materials and activities. Record and map new occurrences and eradication progress with the Non-indigenous Aquatic Species Database; disseminate maps, images and eradication status with the Giant Salvinia web page. Half time biologist: $23,000

- Boat Ramp Education and Inspections: Prepare signs for posting. $1,150

Total estimated cost for national education activities, and inspections at Toledo Bend Reservoir: **$112,300**

Discussion and recommendations:

We recommend the formation of a **Public Information Committee** to coordinate the following activities:

1. Develop an information presentation and information packets to present to the local, county, state and federal legislators which will encourage them to introduce and support legislation to contain giant salvinia.

2. Develop and organize (congressional & legislative) bus trips to giant salvinia sites to encourage funding.

3. Target users thru information with boat registrations and fishing licenses plus articles in magazines that reach fishermen and boaters.

4. Consider using "Salvinia molesta" instead of Giant Salvinia (negative connotation - molesting our native systems).

5. Encourage each state to develop a state Aquatic Nuisance Species management plan.

Recommended Education Strategies:

National:

1. Develop a story to tell the national network and cable TV news shows (*60 minites*, *20/20*, *48 Hours*, *Dateline*, etc.)

2. Develop articles for popular national magazines (*Sportfishing, Hobbyist, etc*.).

3. Develop features for cable fishing, hunting, and outdoor shows.

4. Develop a web site on a non-government location to distribute information on Salvinia Molesta for influencing government funding and legislation.

5. Develop film clip for movie theaters.

6. Develop K-12 curriculum package on invasive species in general, and giant

salvinia in particular.

Regional:

1. Develop video clips for regional distribution.

2. Provide information and technical guidance to local citizen's groups.

3. Develop regional informational packets to science educators (teachers, boy/girl scouts & clubs, 4-H, etc.).

4. Develop an Advanced Placement Student Internship program.

5. Encourage and sponsor public meetings to disseminate information.

6. Establish citizen-monitoring networks (homeowner associations, angling clubs, etc.)

7. Sponsor annual regional conferences for regulatory agencies and citizen's groups in order to streamline the regulatory/permitting process.

Local:

1. Maintain contact with newspaper sports/outdoor writers.

2. Seek signage at boat launches.

3. Develop informational materials for distribution at marinas and bait shops.

4. Develop informational materials for distribution at aquatic plant nurseries.

5. Develop informational materials for distribution at aquarium shops.

6. Develop informational materials for distribution by local agriculture extension agents.

6) Funding

A Giant Salvinia Task Force committee should develop a list of funding sources for giant salvinia control.

Budget

Prevention	$172,500.00
Public Education and Outreach	$146,100.00
Herbicide Program	$176,926.00
Biological Control	$128,000.00
ANS Plans	$600,000.00
Physical Barriers	$50,000.00
Total	**$1,273,526.00**

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Appendix A: Evaluation of Select Factors that Affect Harvester Production Rates

Productivition rates of mechanical harvesting systems is significantly impacted by the number of harvester loads a system must collect during the operation. This is significant because for each load collected, the harvester must offload the material before it can resume harvesting operations. If the harvester is supported by a sufficient number of transport units, this imposed downtime is significantly less than if it must either (a) wait on a transport unit to return to the site, or (b) trasnport the harvest plant material to the shore disposal site itself. Where offloading sites are long distances from the actual harvest site, the harvester may spend more time directly or indirectly involved in the transport process than in harvesting.

Considering the importance of the total number of harvester loads on production rates, the following table was prepared to illustrate the effects of three factors on the number of harvester loads. The three factors evaluated were: (a) plant density at the harvest site, (b) the onboard stacked density (mass/volume) of the plant material being harvested, and (c) the onboard storage capacity of the harvester.

Table 1. Number of Harvester Loads Per Hectare of Vegetation

Harvester Storage Capacity, cubic meters	Stacked Density of Plant Material, kg/cubic meter	Plant Density, tonnes/hectare				
		5	10	20	40	80
7	160	4	8	16	32	64
14	160	2	4	8	16	32
28	160	1	2	4	8	16
56	160	0.5	1	2	4	8
250	320	2	4	8	16	32
500	320	1	2	4	8	16
1000	320	0.5	1	2	4	8
2000	320	0.25	0.5	1	2	4

At a given site, reducing the number of harvester loads can be accomplished in two ways.

1) Increase the storage capacity of the harvester (cubic meters).
2) Increase the stacked density of the plant material (kg/cubic meter).

Increasing the storage capacity of the harvester is fairly straightforward, and the stacked density of the harvested plant material can be increased by onboard processing, typically by some type of compression process. However, commercially available harvesters typically do not employ either of these mechanisms for increasing their productivity rates for bulky plants such as giant salvinia, waterlettuce, and water hyacinth. Due to this and for other reasons, commercially available harvesting systems are typically not included as primary mechanisms for treating these type plants.