Aquatic Plant Problems and Management Necessity in Florida Public Lakes and Rivers

Note: this "white paper", written by Jeffrey D. Schardt, was commissioned by the Florida Aquatic Plant Management Society to highlight the importance of aquatic plant management in Florida waters.

Introduction

This report summarizes aquatic plant management in Florida public water bodies: describing the important role of native aquatic plants for fish and wildlife habitat; explaining how quickly non-native invasive plants can impair water body uses and functions; recognizing the most invasive aquatic plants in Florida and the economic and environmental harm they cause without intensive management; and identifying management accomplishments and the recurring funding necessary to sustain current levels of invasive plant maintenance control.

The Florida Fish and Wildlife Conservation Commission (FWC) is authorized by the Florida Legislature as the state's lead agency to direct aquatic plant management activities (S369.20, FS). There are approximately 460 public lakes and rivers in Florida (sovereignty lands accessible via public boat ramp) that comprise more than 1.26 million acres of fresh water. Collectively, these waters are worth billions of dollars to Florida's economy.

Uses and Values of Florida Public Waters

Florida's public lakes and rivers provide a variety of economic uses and ecological functions, including:

- recreational boating, fishing, hunting, and swimming
- ecotourism
- flood control
- potable water supply
- agricultural and residential irrigation
- commercial fishing
- commercial navigation
- fish and wildlife habitat (including threatened and endangered species)
- hydropower
- enhanced property values

Several economic studies have been conducted by the federal government and the state of Florida related to the values of Florida waters at risk if waters are impaired by aquatic plants.

- $1.5 billion in annual revenues to Florida from freshwater fishing and wildlife observation (1985 U.S. Fish and Wildlife Service Report)
- Orange and Lochloosa Lakes (Alachua County) generated $10 million each year to local economies; a ten-fold reduction in annual revenues was identified when invasive waterhyacinth and hydrilla covered the water surfaces (1986 University of Florida Study)
- $13 million annual value for Lake Jackson (Leon County) (1996 FSU Economic Report)
- $50 million annual value for Lake Tarpon (Pinellas County); more than 700 jobs generating $9 million in wages (1997 FSU Economic Report)
- $40 million in economic values at risk for 27,000-acre Lake Istokpoga (Highlands County) (2004 FSU Economic Report)
- $50 million in economic values at risk on the 67,000-acre Kissimmee Chain of Lakes (Osceola County) (2006 FSU Economic Report)

Aquatic Plants

Most of Florida's public lakes and rivers are shallow, nutrient-rich, and capable of supporting aquatic plants with favorable growing conditions nearly year-round. Diverse aquatic plant communities provide important ecological services, including:

- fish and wildlife habitat
- substrate for invertebrates supporting fish foraging
- direct food source for some waterfowl species
- nutrient assimilation
- shoreline stabilization

Native vs. Non-native vs. Invasive Aquatic Plants

Native aquatic plants are species that evolved in Florida and are usually held in check via environmental factors like temperature, light, nutrient availability, or by direct competition with other plant or animal species. There are hundreds of native aquatic and wetland plant species and most only occasionally interfere with the uses or functions of Florida's public waterways.

Approximately 25 non-native plants are routinely encountered during FWC's annual aquatic plant inventories in public waters. About 95% of public waters in Florida support at least one non-native aquatic plant species. Half of the non-native aquatic plant species found in Florida public waters are considered invasive, and more than 95% of Florida public waters host at least one invasive aquatic plant species. An invasive species is defined as one that is non-native to the ecosystem and capable of rapid expan-

sion, causing economic or environmental harm or harm to human health or welfare.

Invasive Plants

Invasive plants share several characteristics, including:

- ☐ rapid growth to reproductive maturity
- ☐ multiple reproductive methods
- ☐ wide dispersal and survival
- ☐ broad environmental tolerance
- ☐ difficult to manage and sustain control

These traits, coupled with Florida's shallow, nutrient-rich waters, year-round growing conditions, and the lack of biological and environmental controls that kept invasive plants under control in their home ranges, allow invasive plants to quickly expand and impair Florida public water uses and functions.

Plant Growth Patterns

Aquatic plants exhibit several growth forms, including floating, submersed, and emergent, and there are examples of widespread invasive plants for each type. Floating plants drift freely on the water surface with the roots suspended in the water column as opposed to being anchored in the sediments. Submersed plants grow mostly underwater; occasionally, a very small portion of the plant (for example, flower stalks) extends above the water surface. Emergent plants are rooted in the sediments, with much of their mass at or extending above the water surface.

Floating Plants

Florida's most invasive floating plants are waterhyacinth and waterlettuce; both were introduced to the state from South America. Waterlettuce is thought to be an accidental introduction, perhaps as a contaminant in ship ballast or water storage containers during colonial times. Waterhyacinth was introduced intentionally in the 1880s as a horticultural plant because of the beautiful flower.

Waterhyacinth populations can double their coverage in as little as two weeks. If left unmanaged, just a few acres of plants can expand to cover hundreds of acres by the end of the growing season. Both waterhyacinth and waterlettuce reproduce via budding and prolific seed production. Seeds can lie dormant in the sediments, with millions of seedlings germinating upon re-flooding after drought conditions. Thousands of acres of waterhyacinth and waterlettuce germinate as the dry marshes of Lake Okeechobee refill after seasonal drought or drawdowns.

The edges of floating plant mats provide cover for fish, and the suspended roots harbor invertebrates, which supplies food for fisheries. However, light is suppressed just inside the edge of the mat, shading out native submersed vegetation. Dissolved oxygen drops below levels required for fish to breathe and for microbes to break down accumulating detritus falling from the floating plant mass. Leaf, shoot, and root material continually slough from floating plants and can accelerate sedimentation more than twice as fast than if plants are managed on a routine basis to keep levels low.

Waterhyacinth is listed as one of the world's worst weeds. Even small patches of floating plants can coalesce in wind or flowing water, clogging irrigation water intakes, flood control pumps, jamming against bridges, uprooting native plants, and blocking navigation and access to boat ramps, which can strand boaters. Floating plants, especially waterlettuce, also harbor

Waterhyacinth floating on Lake Okeechobee

Early hydrilla infestation in Crystal River

Torpedograss smothering Lake Okeechobee marsh

certain species of mosquitoes.

In addition to waterhyacinth and waterlettuce, three other floating plant species have been introduced into Florida, most likely as curiosities in water gardens. The FWC, through its contractors, funds management programs to contain two species – red root floater and feathered mosquitofern – in isolated watersheds of Southwest and South Florida, respectively. In addition, the FWC sponsors eradication efforts for giant salvinia in about a half-dozen locations from Bay to Collier County. Giant salvinia is also listed as one of the world's worst weeds and is causing millions of dollars of impacts, especially in Texas and Louisiana.

Hydrilla surface mat on Lake Toho

Submersed Plants

Hydrilla is by far the most invasive submersed plant growing in Florida public waters. Hydrilla was introduced intentionally through the aquarium trade during the early 1950s. Plants were discarded in canals and planted in rivers and spring runs for harvest, sale, and shipment as needed. In early infestations, hydrilla mimics the low growth and open nature of native submersed plants, providing fish and wildlife habitat, especially in deep water/low light areas where native submersed plant species do not grow. However, because of its rapid growth rate and canopy forming nature, hydrilla quickly smothers native submersed plants and impairs public lake and river uses and functions.

Waterlettuce covering channel on Rodman Reservoir

Although the variety of hydrilla in Florida waters does not form seeds, it has numerous methods by which it reproduces, spreads, and persists. Even small fragments can break loose, drift to other areas, form roots, and start new plants. Stolons spread across the sediments, generating new plants as they grow. Stressed plants produce small winter buds (turions) in the leaf axils that float, drift, and start new populations elsewhere. Hydrilla also produces pea-size buds (tubers) in the sediments by the millions per acre that sprout throughout the year. When the standing crop is controlled, subterranean tubers sprout and renew the infestation.

Perhaps hydrilla's most invasive traits are its growth pattern and rate. Hydrilla needs far less sunlight than native submersed plants for growth. Therefore, it can colonize deeper waters, and its growth season starts before and extends later in the year than native plant species. Hydrilla grows about an inch or more per day from the apical tips, but stems can elongate by eight inches or more per day during the peak growing season from July through September. Growth slows but continues laterally when hydrilla stems reach the

Explosive waterhyacinth seed germination and growth on Lake Okeechobee following drought

Dense hydrilla growth

water surface to form dense tangled mats. A single stem sprouting from one tuber can branch up to 200 times and there can be millions of tubers per acre.

In early stages of infestation, hydrilla mimics native submersed plants by providing cover and substrates for invertebrates fed upon by sport fish. Mature hydrilla stands can provide an edge or reef effect to shelter fish or provide ambush cover for largemouth bass. Without intensive management, hydrilla can fill the water column in Florida's shallow waters within a few months, which ultimately suppresses the fishery it first enhanced. Even when infestations are intense, hydrilla provides easily accessible forage for some waterfowl species.

Most of the biomass in a mature hydrilla stand is in the upper two feet of the water column. These dense mats cause extreme fluctuations in water temperatures, pH, and dissolved oxygen content, making it difficult for fish and their invertebrate forage to survive. Oxygen content can approach zero in dense hydrilla mats by early morning or during prolonged cloudy days when plant respiration exceeds photosynthesis. Photosynthesis is a plant process during which carbon dioxide is converted to oxygen under sunlight conditions. During dark conditions or extended cloudy days, plants respire, consuming oxygen and producing carbon dioxide. Some of the largest fish kills in Florida waters are attributable to the oxygen-consuming properties of dense hydrilla mats. Similar to waterhyacinth, the organic material that sloughs from live hydrilla mats builds up about twice as fast as in open water, covering valuable habitat and accelerating muck buildup on lake and river bottoms.

Emergent Plants

Emergent plants are rooted in the sediments with stems or leaves extending above the water surface. Several invasive emergent plant species threaten native marsh and wetland plant communities. Torpedograss was introduced into Florida as a cattle forage in the 1920s and now is one of the most widespread invasive plants in the state, infesting the shores and marshes of more than 80% of Florida's public lakes and rivers. Two more recent invaders – large-flower primrose and bur-head sedge – are

Large flower primrose covering fish and wildlife habitat on Lake Toho

expanding and covering diverse native grass and bulrush communities (which provide valuable cover and food sources for fish and waterfowl) and forming floating masses of

Floating cattail tussock drifting toward the Lake Apopka flood control structure

Hurricane Charley broke this 35-acre floating island of 4 feet thick peat and trees up to 25 feet on Lake Pierce

vegetation from Central to North Florida. Both of these plants were identified during FWC's annual plant inventories during the 1980s, but had little impact on water uses and functions until recent years. Each species is quickly expanding both within infested waters and into adjacent waters, causing problems to the extent that they have become high management priorities.

Floating Islands and Tussocks

The FWC characterizes tussocks as floating masses of herbaceous emergent plants that are not anchored to the sediments. Tussocks can cover a few square yards to more than 1,000 acres. Floating islands consist of sediments like muck or peat that are up to four feet thick and can support emergent plants or trees up to 40 feet tall. Historically, periodic droughts compacted organic sediments and associated fires burned off accumulations of plant material on exposed lake bottoms. Additionally, periodic flood events thinned emergent and submersed vegetation and flushed organic material into surrounding marshes and uplands. Today, water levels are stabilized in most public lakes in Florida by active flood control gates or passive weirs, causeways, or spillways, or through channelization to connecting lakes and rivers. Residential development surrounding most public lakes precludes flooding and large-scale prescribed fires for safety and economic reasons. Residents and business owners usually object to periodic drawdowns because they may lose the use of the water body for several months. Stabilizing water levels in Florida's shallow, nutrient-rich lakes creates ideal conditions for increased plant growth and at the same time removes the natural processes that used to retard floating island and tussock formation.

When fixed in place, floating islands and tussocks are usually not a problem and provide wildlife habitat. However, when they drift, they can damage docks, bridges, and flood control structures. They can also block boat ramps and navigation channels, which can strand boaters. Management costs range from a few hundred dollars per acre to apply herbicides to small tussocks to more than $20,000 per acre to harvest, transport, and dispose of thick peat islands with overlying tree growth. Managers spent up to $10 million per year for several years after the 2004 and 2005 hurricanes broke thousands of floating islands and tussocks loose in nearly 50 Central Florida lakes and rivers.

FWC Aquatic Plant Management Strategy

The FWC aquatic plant management approach is to work with stakeholders to identify the primary uses and functions of all Florida public waters and to manage plants to conserve these attributes. This includes managing native as well as non-native and invasive aquatic plant species. FWC attempts to eradicate invasive aquatic plants that have not become established in the state to prevent spread into Florida public waters. FWC contractors also work to eradicate newly discovered populations of invasive aquatic plants in a public water body that may already be present elsewhere in Florida, but were not previously established in that system. In both cases, the intent is to prevent long-term and costly management programs. If an invasive plant becomes well-established in a Florida water body, the management strategy shifts to maintenance programs to keep invasive plants at low enough levels to conserve or enhance the primary uses of the water body.

FWC is designated by the Florida Legislature as the lead agency with both the responsibility and accountability to develop and implement statewide, consistent, and cost-effective aquatic plant management strategies. This requires sufficient and well-trained staff to assess conditions, implement operations, and monitor results, both in terms of contract compliance and efficacy in controlling target plants while conserving non-target plants and animals. Appropriate contractors and materials are necessary to quickly respond to any aquatic plant management-related issue and to adapt to control new plants, changing conditions, and to apply new technologies. The FWC has at least two contractors available to immediately implement management operations on any Florida water body.

Research to integrate new control technologies and to adapt to changing

conditions, as well as outreach to inform and train biologists and control crews with latest management strategies, are essential for long-term management stability. See below for the types and numbers of FWC aquatic plant management-related contracts. Also essential is sufficient, dedicated, and recurring funding to sustain the current low levels of invasive plant infestations in Florida public waters.

FWC Aquatic Plant Management Contracts (total: 55 in 2015)

- ☐ 27 contracts with private sector companies
- ☐ 14 aquatic plant control contracts with Federal, state and local governments
- ☐ 11 research contracts to develop control methods and evaluate management strategies
- ☐ 3 contracts to develop and distribute education, training, and outreach materials

Management Results and Funding Requirements Overview

With few exceptions, invasive plants and nuisance growth of native aquatic plants are under maintenance control in Florida public lakes and rivers. Sustaining this level of control requires

frequent management efforts throughout the year. That management is contingent upon sufficient, dedicated, and recurring funding and ongoing research to adapt to ever-changing conditions and management challenges.

Prior to 1999, aquatic plant management funding was generated primarily from boat registrations and fuel taxes; however, this funding was insufficient to keep pace with invasive plant colonization and expansion. Consequently, hydrilla spread within and among Florida's largest and most important water bodies, reaching its apex of nearly 100,000 acres during 1994. Stopgap funding was obtained from other programs for several years, but this piecemeal approach did not allow for long-range planning and management. The Florida Legislature resolved the funding dilemma in 2000 by providing sufficient, recurring funds for aquatic plant control via the Florida Forever Act. The rationale was that a portion of the funds used to acquire sensitive lands was to be used to control aquatic plants to conserve economic and environmental attributes of state-owned aquatic and wetland sites.

Aquatic plant management plans were authorized by the FWC on more than 430 public waters in FY 2014-2015. Over the past five years, an average of nearly 70,000 acres of aquatic plants have been controlled per year at an average annual cost of $19.2 million. That level of control and corresponding funding needs to be consistent to sustain management achievements, or plants will re-grow and the gains of the past decade will be lost in a matter of one or two growing seasons.

Floating Plants

Once established, invasive aquatic plants have proven difficult to impossible to eradicate from Florida public waters. However, negative impacts can be minimized when invasive plants are managed on a frequent and consistent basis to prevent small infestations from expanding across hundreds or thousands of acres. This concept is known as maintenance control and has been the cornerstone, as well as Legislative mandate (S.369.22(3), FS), of Florida's invasive aquatic plant management program since the mid-1970s.

Figure 1 shows the benefits of floating vegetation maintenance control along the Suwannee River from 1974-2014. Until the early 1970s, floating plants were often allowed to grow until conditions became intolerable, resulting in the need to control

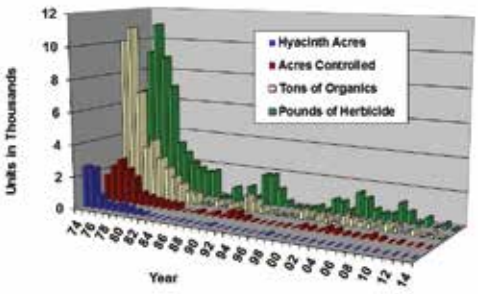

Figure 1. Suwannee River waterhyacinth presence and management - 1974 - 2014

hundreds of acres of plants to restore water body uses and functions. Plants quickly recovered and the cycle repeated. This type of crisis management not only leads to impaired waters from floating plants, but also results in higher management costs, higher herbicide use, and increased sedimentation from controlled plants (in addition to material sloughing from live plants). The maintenance control management strategy was implemented statewide – including the Suwannee River – by the late 1970s. Nowadays, only a few acres of floating plants ever infest the Suwannee River at any one time. Any plants flushed into the river from adjacent marshes or private lands are quickly and economically brought back under control to conserve the native plant communities along the river.

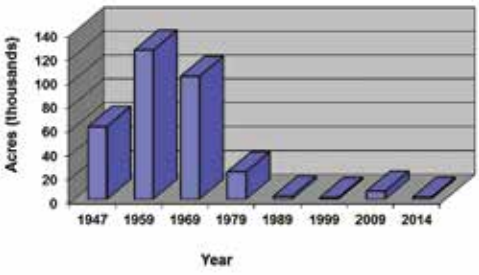

Figure 2. Waterhyacinth acres in Florida public waters: 1947-2014

Figure 2 demonstrates the results of waterhyacinth maintenance control on a statewide level. Nearly 125,000 acres of floating plants infested Florida public lakes and rivers in the early 1960s. Nowadays, the cumulative statewide standing crop ranges between 5,000 and 8,000 acres. Waterhyacinth and waterlettuce collectively are present in about 60% of Florida's public waters; however, 85% of these waters support fewer than 10 acres of floating plants. Floating plants are considered to be under maintenance control in about 99% of Florida's public lakes and rivers. However, these waters can be quickly impaired by remnant plants and the long-lived seed bank within Florida waters and by plants flushing in from adjacent marshes and canals that are often inaccessible to FWC management crews. Managers need between $4.5 and 5.5 million annually to keep floating plants under control in Florida public waters.

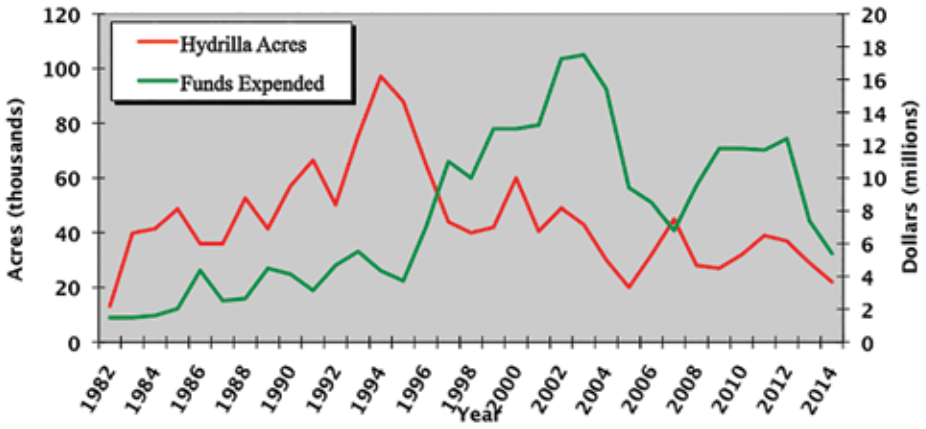

Figure 3. Relationship between hydrilla and management funds in Florida public waters 1982-2014

Submersed Plants

Hydrilla is by far the most problematic of the invasive submersed plants in Florida public waters; it is found in more waters, covers more acreage, and requires by far more management efforts and funding to keep under maintenance control than any other species. Figure 3 shows the relationship between available funding and hydrilla cover in Florida waters over the past 32 years.

When funds are sufficient, hydrilla can be managed at a low level. When funds decline, hydrilla expands to a higher level within infested waters and to adjacent waters, requiring additional recurring funding for control. Hydrilla reached its apex in Florida public waters in 1994, when the species covered nearly 100,000 acres. Although the standing crop in the collective 185 waters where hydrilla was reported in 2014 totaled about 21,836 acres, underground tubers, which represent hydrilla's ability to immediately sprout and refill the water column, are estimated at about 60,000 acres. Therefore, the FWC must remain diligent in controlling this highly invasive aquatic plant to prevent it from impairing Florida's public waters. Suppressing hydrilla allows diverse native plant communities to flourish and conserves recreational uses. Additionally, sustaining low levels of hydrilla through time reduces taxpayer management expenses and allows the FWC to meet its federal obligations to reduce herbicide use in Florida waters.

Hydrilla has been reported during annual aquatic plant inventories in 365 (80%) of Florida's 460 public waterways over the past 32 years. The highest acreage (97,000 acres) was reported in 1994 and the highest management cost of $17.5 million reported in 2003. Persistent management, consistent funding, and improved research and technology have allowed managers to reduce hydrilla to 185 (40%) of Florida's public waters and a standing crop of about 22,000 acres, which is comparable to levels reported in the early 1980s. Annual management costs continue to decline while meeting management objectives. The average hydrilla control cost over the past five years is about $8.5 million per year.

Other Plants, Tussocks, and Floating Islands

About $3.5 to 4.0 million are required each year to control about 8,000 acres of aquatic plants other than waterhyacinth, waterlettuce, and hydrilla. In recent years, most of that amount has been spent controlling two invasive emergent plants – bur-head sedge and giant flower primrosewillow. These plants are expanding into valuable fish and wildlife habitat throughout the Kissimmee Chain of Lakes and other important resources in Central Florida. Research is underway to learn more about the physiology of these plants and to develop cost-effective and selective control measures.

Jeff Schardt (jeff.schardt@gmail.com) recently retired from the Florida Fish and Wildlife Conservation Commission and is now the APMS Secretary.