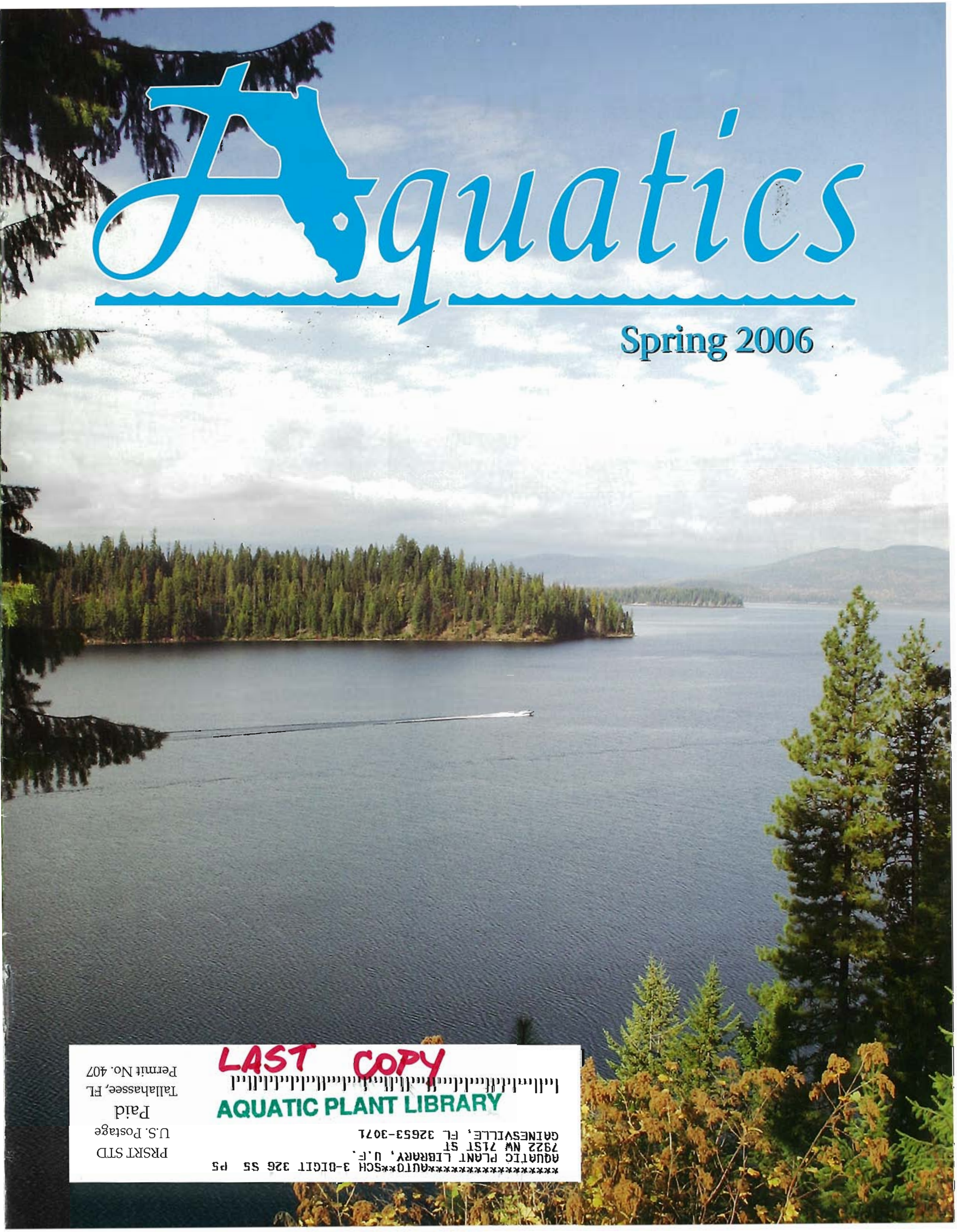
Aquatics

Spring 2006



Manage The Pond Cycle

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Editorial

Restoring Sport Fishing at Lake Apopka

By Stephen Murphy, Mark Hoyer, and Daniel Canfield Jr.

Florida has spent enormous amounts of money to restore Lake Apopka, but the efforts to date have only made some progress. Completion of the restoration efforts could take decades without the actions recommended in this article. While this article focuses on restoring the largemouth bass fishery, the reestablishment of the largemouth bass fishery would benefit other recreational activities. Lake Apopka has a viable black crappie fishery as well, and once anglers recognize

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EDITORIAL: Address all correspondence regarding editorial matter to Jeff Holland, *Aquatics Magazine*. Cover photo: Priest Lake, Idaho; David Tarver.

Landoltia punctata, Lake Co. Florida

Aquatic Plant Resistance to Herbicides

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Recently, aquatic plant managers have been introduced to the reality of weed resistance to aquatic herbicides. In Florida, hydrilla (*Hydrilla verticillata* (L.f.) Royle) has developed resistance to fluridone (MacDonald et al. 2001, Arias et al. 2005), and a species of duckweed (*Landoltia punctata* (G. Meyer) D.H. Les and D.J. Crawford) was identified that developed resistance to diquat (Koschnick 2005). Although the full extent of fluridone resistant hydrilla (FRH) is not known, it occurs in many of Florida's largest water bodies that have had historical hydrilla problems. Diquat resistant duckweed is less widespread. Weed resistance to aquatic herbicides is an emerging issue in aquatic plant management, and education and research are keys to managing this problem.

Herbicide Resistance and Tolerance

First, what is resistance? Resistance occurs in a plant species that was originally susceptible to an herbicide, but over time control is lost through the selection of an existing resistant individual or biotype. Think of it as a form of natural selection. There are slight genetic differences between plants in the same population. When the same herbicide is used repeatedly, a strong selection pressure is exerted for individuals with the genetic make-up that allows these plants to resist the herbicide and survive, and then increase their presence in the population. It is important to emphasize that the herbicide does not cause a mutation or create a super plant, and you can't visually discern the difference between a resistant versus susceptible individual. For example, hydrilla was initially susceptible to low use rates of fluridone, but over time a population was selected that was no longer controlled at these recommended use rates, and the appearance of the individual plant is the same. Additional applications of fluridone facilitated the spread or increased the proportion of a resistant biotype throughout the waterbody.

There are also concerns about cross-resistance, which is resistance to different herbicides with similar modes of action. This should not be confused with multiple resistance, which is resistance to multiple herbicides with different modes of action. Experimentally, we have shown cross-resistance under laboratory conditions. Diquat resistant duckweed is also resistant to paraquat because both these herbicides kill the plants by stopping the same biochemical process. In hydrilla, fluridone inhibits the enzyme phytoene desaturase. FRH is also resistant to norflurazon and several other herbicides that inhibit the same enzyme. There have been no cases of multiple resistance or resistance to at least two different modes of action by aquatic plants.

In contrast to resistance, tolerance is the term used to describe plants that have never been susceptible to a particular herbicide or class of herbicides at labeled use rates. For example, aquatic grasses tend to be tolerant of compounds such as 2,4-D and triclopyr. Likewise, a plant such as hygrophila has proven to be fairly tolerant of all currently registered aquatic herbicides. While the terms resistance and tolerance have often been used in the same context, they have very different meanings to those in the field of weed science. Resistance is the result of a trait that is selected for, whereas tolerance is

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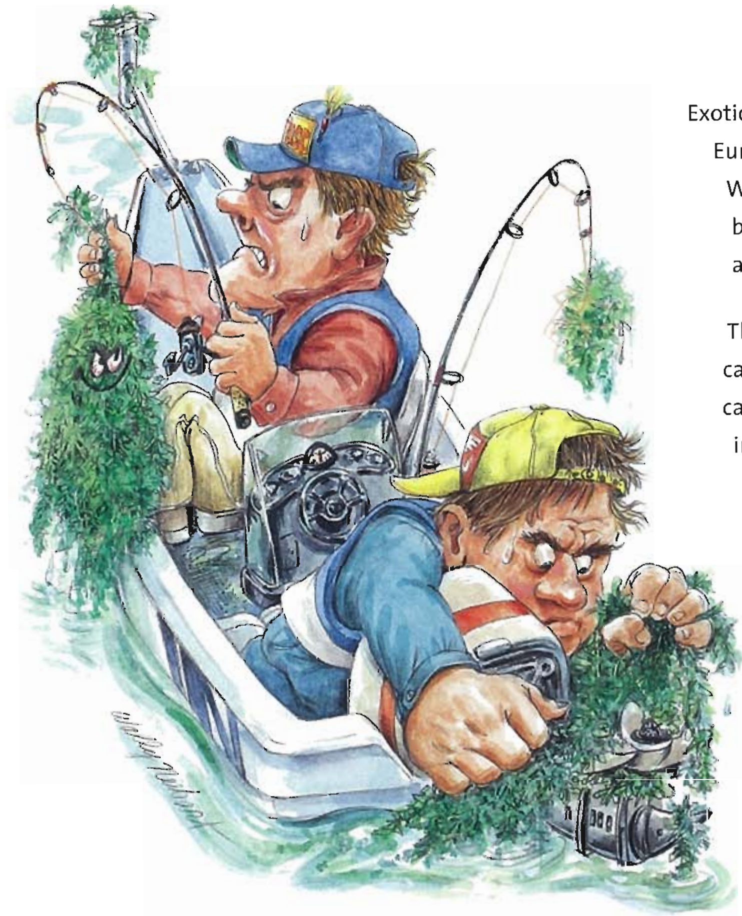
Too Many Weeds Spoil the Fishing



Exotic invasive aquatic plants such as Hydrilla, Eurasian Watermilfoil, Curlyleaf Pondweed, Water Chestnut and Water Hyacinth can be detrimental to a healthy fishery in lakes across the country.

These invasive plants when left unmanaged can alter the ecosystem of lakes and reservoirs, causing a decline in the fishery, as well as interfering with other valued uses of waterbodies.

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an inherent ability to survive the herbicide application. Tolerance may be biochemical (e.g. metabolism), the result of reduced uptake (e.g. thick cuticle), or other means that allow some plant species to tolerate the herbicide.

In theory, "every" plant species has a biotype that is resistant to "every" herbicide. The question becomes: Has it been selected for yet? The chances of selecting for that "one" individual increases in areas with repeated use of the same herbicide and widespread weed populations. Resistance is not a new subject with herbicides, but it is new in aquatics. There are currently over 177 plant species (>295 biotypes) that have developed resistance to herbicides worldwide, with approximately 70 species in the US, with most occurring in agricultural systems (www.weedscience.org).

There are four main mechanisms of herbicide resistance in plants. Some herbicides target or prevent formation of a key enzyme. Resistant biotypes have an alteration at the site of action that prevents an enzyme-specific herbicide (e.g. fluridone, ALS inhibitors) from affecting the target site. Resistance can also result in biotypes that have greater ability to metabolize or detoxifiy the herbicide (e.g. substituted ureas). Herbicides can also lose their effectiveness due to being compartmentalized or bound-up prior to getting to the site of action, or due to reduced transport or movement of the chemical (e.g. glyphosate). Finally, resistant biotypes may have reduced uptake of the herbicide into the plant or movement to the site of action inside the cell.

There are certain characteristics of herbicides that can lead to an increase in the development of resistance. Some herbicides, such as copper and endothall, kill cells by destroying membranes and shutting down respiration and photosynthesis, essentially affecting several cell processes simultaneously. In contrast, the more specific (simple) the mode of action the greater the chance of selecting for a biotype with one of the 4 resistance mechanisms. Herbicide characteristics and use patterns that favor resistance include: 1) use of compounds with similar or single modes of action; 2) persistence in the environment; and 3) products that are commonly or repeatedly used (high market share) due to the lack of effective or cost-effective alternatives.

Aquatic Plants and Herbicide Resistance

How many duckweed plants in a 10-acre pond? Ten billion? That is not out of the question if you assume a frond is 0.125 inches long by 0.0625 inches wide and consist of a single layer of plants (~800 million per acre). Even if 0.0000001% of the duckweed plants have one of these 4 resistance mechanisms (altered site of action, metabolism/detoxification, reduced transport, or reduced uptake/movement to site of action) and 9,999,999,999 plants are killed by your treatment, 1 may survive. Dense infestations of hydrilla and duckweed are characterized by the presence of huge numbers of meristematic growing points in an aqueous environment. Moreover, this is also characteristic of numerous other aquatic plants.

Weed characteristics can also contribute to the development of resistance, especially characteristics that can increase genetic diversity in the weed population. These characteristics may include species with high reproductive rates (e.g. high seed production, asexual budding), short seed longevity, and species with naturally diverse genetic make-up. Also, once a species develops resistance, the resistant biotype must be able to compete and survive against susceptible biotypes in the absence of further selection pressure.

To reduce the chances of resistant populations developing in the aquatic environment the following practices are recommended: 1) alternate modes of action or use herbicide mixtures 2) utilize chemical, biological, and mechanical control options when feasible; 3) do not use herbicides with the same mode of action repeatedly, and 4) treat weeds when infestations are low. By following these recommendations, you will reduce the chances that a "single duckweed plant" will survive long enough to create a large population of resistant plants. The main key to weed resistance management in terrestrial systems has been alternating crops and herbicide modes of action. While we are limited in our ability to alternate our "weeds" in aquatic plant management, we can consider changing our herbicides or mixtures.

Aquatic weed control is conducted with very few herbicide choices, and managers are often heavily dependent on one or two standard herbicides for a particular weed species. Factors impacting these use patterns include cost-effectiveness, use restrictions, and selective properties of the herbicide. This reliance, coupled with the limited number of herbicides registered in aquatics, surprisingly has not resulted in widespread development of more resistance issues. While techniques such as biocontrol and mechanical control are well known, herbicide programs are generally implemented when neither of these options is feasible due to the scale of the problem or the need to provide predictable management results. Moreover, issues such as crop rotation, herbicide rotation, and pest scouting that are familiar to traditional integrated pest management programs in terrestrial agriculture have not proved to be easily incorporated into aquatic plant management programs. Therefore, in aquatics we are unable to utilize many terrestrial weed recommendations for reducing the potential for resistance development.

Mueller et al. (2005) discuss proactive weed management versus reactive weed management as it pertains to resistance. Most people employ a reactive strategy, which means "don't do anything until resistance occurs", since it won't

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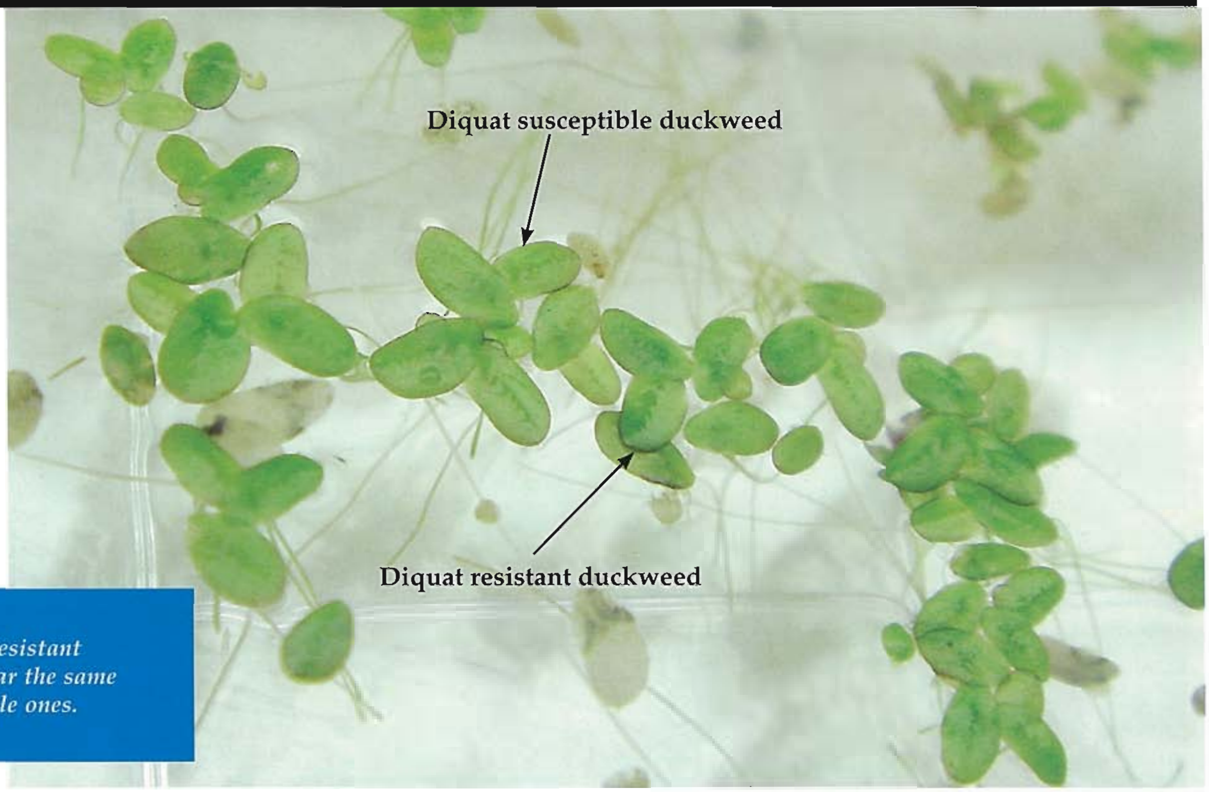

Individual resistant plants appear the same as susceptible ones.

happen to me in "my lake". This is driven by economics and often we wait until weeds are widespread (crisis) in order to gain public support and funding for operations. It is difficult to switch to more expensive management methods due to the priority of controlling weeds at the lowest cost in public funds. The proactive strategy involves determining what you can do to delay the onset of resistance since it will eventually happen in "my lake", and try to protect the currently registered products. Rotate herbicides, don't treat every year with the same mode of action at the same site, and use herbicide mixtures. However, this strategy typically comes at a cost, and scientists have not yet determined the most practical means of accomplishing this.

New Product Development and Resistance Considerations

The Agrichemical industry and state/federal scientists are trying to bring new herbicides and tools to the market to give managers more options for managing aquatic plants. In the last 5 years, 3 new herbicides have been registered for aquatics (triclopyr, imazapyr, and carfentrazone). Currently, there are 4 additional herbicides with experimental use permits (EUP) granted by EPA or applied for (penoxsulam, imazamox, flumioxazin, and bispyribac sodium), and hopefully more will be submitted for EUP status in the near future. While these new EUP products typically have good toxicity profiles that will aid in the aquatic registration process (some are classified as reduced risk products), they also have a single site of action in plants, which increases the chances for resistance to occur.

For example, 3 of the herbicides currently being developed for hydrilla control are classified as acetolactate synthesis (ALS) inhibitors (penoxsulam, imazamox, and bispyribac sodium). ALS-inhibitors affect a single enzyme necessary for amino acid/protein synthesis in plants; acetolactate synthase, and there are about 50 ALS-inhibiting herbicides registered in the U.S. While most of these ALS compounds will likely prove active on hydrilla, resistance development to one of these products could lead to wide-scale cross-resistance (Tranel and Wright 2002), or resistance to all 50+ ALS-inhibiting herbicides. Resistance to ALS inhibiting herbicides has occurred in terrestrial sites over a relatively short period of time (few years) compared to other herbicide families such as the triazines (10 to 20 years). The first documented case of resistance was only 5 years after ALS herbicides were commercialized in 1982. Today, there are more plant species resistant to ALS herbicides than any other herbicide, including the triazines, which have been used for approximately 20 years longer than the ALS herbicides.

There are numerous species of wetland plants [e.g. *Limnophila sessiliflora* (Vahl) Blume] that have developed resistance to ALS herbicides in rice, and over 16 plant families have representative species that have developed resistance to ALS inhibitors (Heap 2005). This suggests that ALS resistance will occur in submersed aquatic species, unless active steps are taken to prevent this from happening. While recognition of this potential is an important first step, it is also important that resistance management strategies be put in place prior to wide-scale use of these products.

Based on the experience with large-scale fluridone use and the proven ability of hydrilla to develop resistance, developing programs for resistance management are critical to protect the long-term viability of ALS herbicides. In addition to ALS chemistry, there is a strong need to identify an alternate mode of action that can be used in rotation with other management tools.

The number of herbicides or modes of action for use against hydrilla is limited. There are approximately 300 herbicides registered in the US representing 6 general modes of action (photosynthetic inhibitors, amino acid/protein synthesis inhibitor, cell division/growth inhibitors, cell membrane disruptors, pigment synthesis inhibitors, and growth regulators). Many of these compounds are too toxic for aquatic use (diuron, trifluralin, etc.), many do not control hydrilla (2,4-D, glyphosate, etc.), and many are off patent (dicholbenil, simazine, etc.), which greatly reduces the potential for incurring high registration costs. Decisions on registration and use of aquatic herbicides made in the next few years will determine managers' abilities to control aquatic weeds, particularly hydrilla, 20 years from now.

The situation in Florida for hydrilla control is particularly problematic because of the widespread occurrence of fluridone resistant hydrilla in many of the economically important large lakes of central Florida. If a cost-effective ALS-inhibitor is registered for use by 2007, there will be pressure for frequent use of this herbicide. If the ALS-inhibitors are used annually, will resistance to ALS-inhibitors also occur, making hydrilla resistant to both fluridone and ALS compounds? Then what? Ideally, to protect the use of ALS compounds in fluridone resistant hydrilla, we need another mode of action. The herbicide rotation should at least be ALS-new mode of action-ALS-new mode of action. In waters where fluridone susceptible hydrilla occurs (in parts of Florida and rest of the U.S.) then registration of the ALS inhibitors will provide one more tool that can be rotated with traditional chemistries and other control techniques. In this way, the chances of developing fluridone or ALS resistance (or any herbicide mode of action) should be greatly reduced.

Currently, resistance to aquatic herbicides is isolated to Florida. There are no documented cases of resistant aquatic plant species outside Florida. Yet, resistance will not be a problem isolated to Florida, and duckweed and hydrilla are likely not unique in their ability to develop resistance. It is best to take a proactive strategy where and when you can to delay resistance. While this may result in incurring greater costs in the short-term, the loss of our limited aquatic herbicides is a much greater cost in the long run.

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Evaluation of Water Lettuce's Susceptibility to Diquat: Concerns About Resistance Development

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Introduction

Diquat has been used in Florida for the past several decades to control many floating aquatic weeds. Recently, a population of duckweed (*Landoltia punctata*) was identified in Florida that developed resistance to diquat. This documentation has led to speculation that other populations of duckweed and other floating species have developed resistance to diquat. Diquat is used quite extensively on Lake Okeechobee to control water lettuce and other floating weeds. Recent applications have failed to provide adequate control, and many speculate that water lettuce has developed resistance to diquat. Therefore, the response of a population of water lettuce collected from Lake Okeechobee that apparently recovered from a diquat treatment was compared to a water lettuce population that has never been knowingly treated with diquat to determine if the population has developed resistance to diquat.

Materials and Methods

Water lettuce was collected from King's Bay in Lake Okeechobee (denoted Lake Okeechobee population), where it had been repeatedly treated with less than labeled rates of diquat over the previous 4 months. The most recent diquat application was approximately 30 days before collection. This population was suspected of being diquat resistant, as it appeared to recover from diquat treatment. Another population of water lettuce (denoted Sante Fe population) was collected near Sante Fe Community College, Gainesville, FL, and has never knowingly been exposed to diquat.

Ten individual water lettuce plants were placed into 25 gallon plastic tubs (22.8 in diameter) for each population, and allowed to establish 14 d before herbicide application under ambient conditions. Diquat was applied through a CO_2 powered sprayer. An equivalent of 80 gpa was applied to each pot containing lettuce, with 0.625% Sunwet® (methylated seed oil) surfactant. Water lettuce was treated with diquat at rates equivalent to 0, 0.02, 0.04, 0.06, 0.12, 0.18, 0.36, and 0.72 lbs. diquat/acre. The experiment was a completely randomized design with 3 replications. All plant biomass was harvested 21 d after treatment, and placed into a forced air drying oven. Dry weights were determined, and due to biomass differences between populations (Lake Okeechobee plants were smaller than Sante Fe plants), dry weights were converted to percent of untreated controls for each accession.

Results and Discussion

There were no differences in response to diquat between the two water lettuce populations at any rate tested (Figure 1), even at rates that caused less than 100% control. Additionally, both populations of water lettuce exhibited a rate response to increasing rates of

St. John's River Water Management District personnel spraying dense infestation of floating plants.

diquat. Under these experimental conditions, the Lake Okeechobee population that recovered from a recent diquat treatment was equally as susceptible to diquat as a population with no history of diquat treatment (Sante Fe). Although it is possible that additional species, besides duckweed, could develop resistance to diquat, this population of water lettuce from King's Bay has not developed resistance to diquat. If diquat failed to provide adequate control, increased rates of diquat or increased diluent may be considered to improve coverage and efficacy.

Water lettuce from Lake Okeechobee should be monitored for resistance development in the future if concerns over susceptibility arise as diquat has been used almost exclusively in the past for control. To minimize the chances of resistance development in the future, herbicides with different modes of action should be alternated when controlling water lettuce and other floating plants. By rotating herbicides or sometimes tank mixing diquat with different modes of action, such as imazapyr, glyphosate, or carfentrazone, selection of a resistant biotype may be delayed or eliminated.

After herbicide applications are made to floating weeds, treated areas should be scouted for non-injured target plants. Those areas which have been treated repeatedly with diquat for years need to be especially monitored for potential resistant populations. Possible reasons for lack of control besides resistance include misapplication, heavy weed pressure, potential weather effects, and misjudgment of control. Misapplications could be the potential problem when healthy plants are existent among dying plants. Sometimes target plants are missed with the herbicide solution and this is reason for the perception of a failed applications. Additionally, heavily infested mats of water lettuce, water hyacinth, or duckweed can conceal or screen smaller individual plants under the mat, resulting in an escape from direct herbicide exposure.

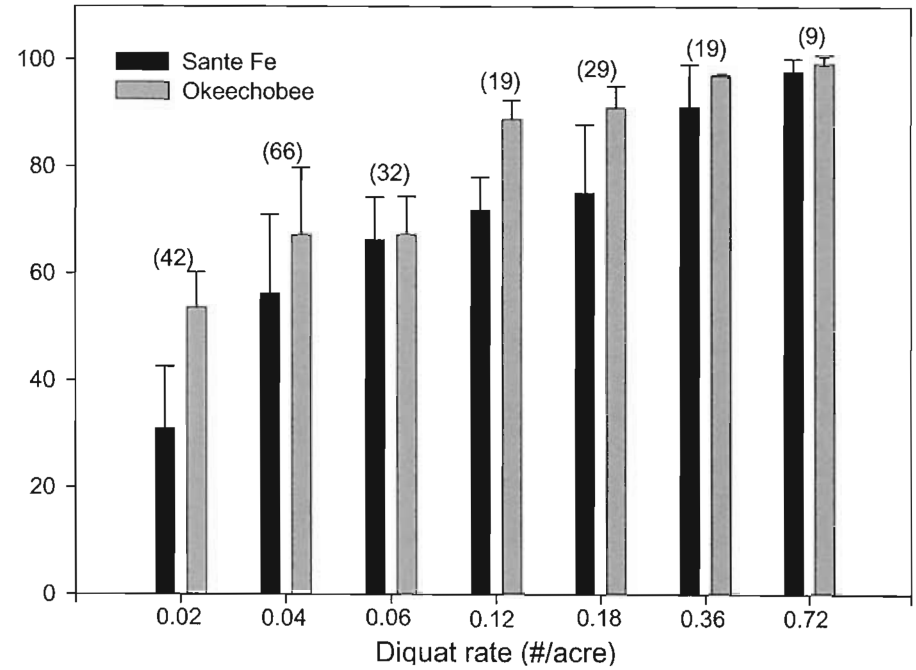
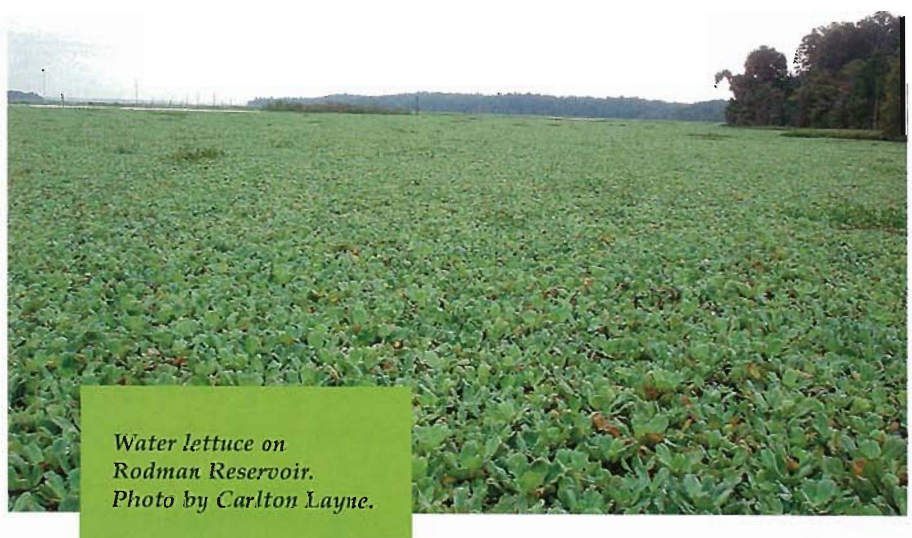


Figure 1. Diquat effects on two populations of water lettuce. Sante Fe population had no previous history of herbicide treatment, and the Lake Okeechobee population was suspected of developing resistance to diquat. Values reported as means±standard error, with LSD values ($p \leq 0.05$) for between population comparison for each rate in parentheses.

These individuals begin to establish and appear to be unaffected by the herbicide application as the larger surface plants that received herbicide exposure die. Increasing diluent amounts may aid in increased coverage of heavily infested areas. Expected weed control versus actual weed control is sometimes very different. Complete eradication of weeds after a treatment is always desired, but rarely occurs. These expectations may lead to the perception of poor weed control when some plants have foliar damage, but are not controlled, potentially leading managers to believe that the plants have developed resistance to a herbicide.

Acknowledgements

Thanks to Tim Harris, USCE-Palatka, for collecting water lettuce accession from Lake Okeechobee.



Water lettuce on Rodman Reservoir. Photo by Carlton Layne.

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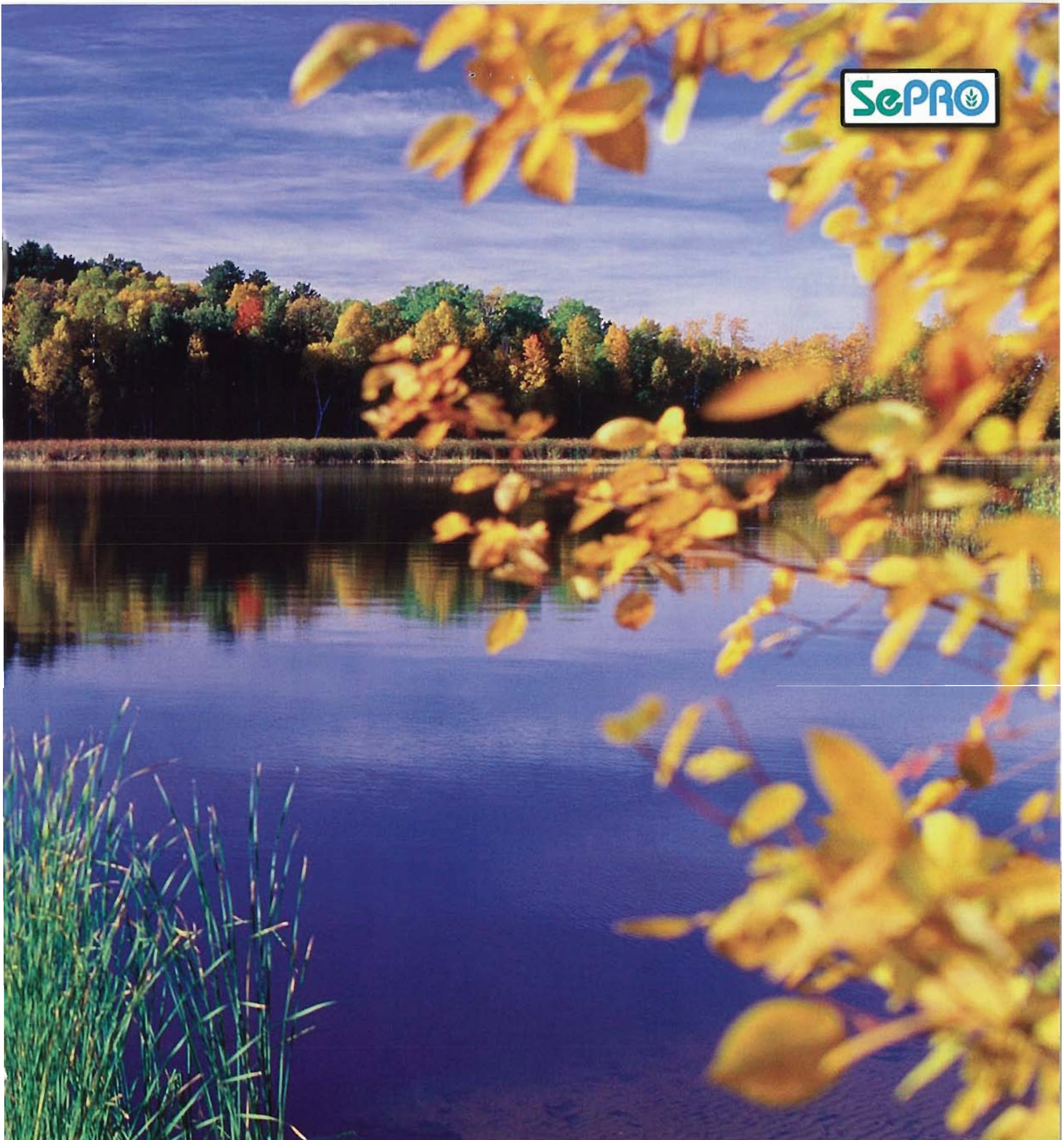
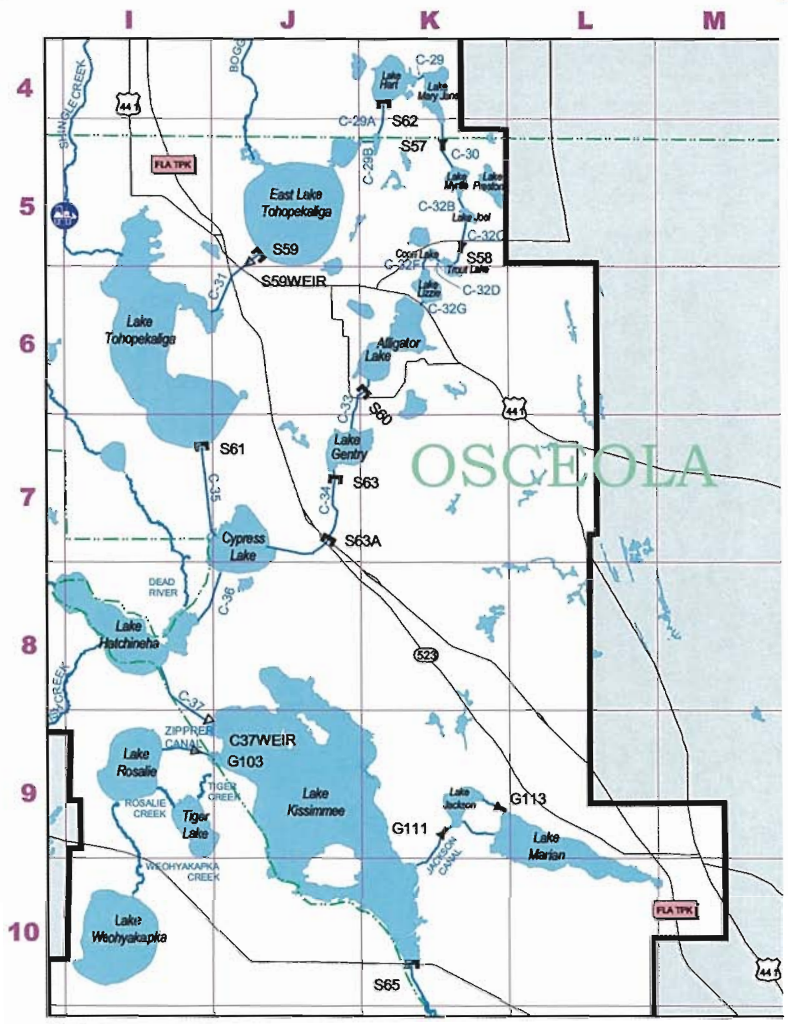

SePRO

The Kissimmee Interagency Group

By Ed Harris



Map of the Kissimmee Chain of Lakes (KCOL) and connecting waterways. .

The Kissimmee Chain of Lakes (KCOL) is one of central Florida's most unique and diverse waterways. The chain is comprised of a series of interconnected lakes that are the headwaters of the Kissimmee River and, ultimately, Lake Okeechobee. These lakes were connected as part of the Central and Southern Florida Flood Control Project, which was initiated in 1948 as a US Army Corps of Engineers (Corps) project. The aquatic plant components that are part of the overall lake management goals incorporate several challenging concerns that include flood protection, endangered species management, recreational boating, and fishing.

In the 1980s, there were several state agencies and one federal agency charged with managing the KCOL resources. The Florida Department of Natural Resources (DNR) was the lead agency for aquatic plant management and the South Florida Water Management District (SFWMD) functioned as their contractor, in addition to their other functions related to flood control. The Florida Game and Freshwater Fish Commission (GFC) was primarily interested in managing aquatic organisms for public benefit and the Corps was responsible for maintenance of the federal navigable waterway. Early on, it became obvious that each agency had a specific set of goals to achieve with regard to management of the lakes and that these goals were not always similar.

One of the first indications that agency goals might be in conflict came about after concerns were raised about negative impacts to bulrush and other desirable species from the DNR/SFWMD floating plant control program. At the time, maintenance control of floating vegetation was inconsistent and was not uncommon for water hyacinth and water lettuce to cover large areas before being controlled. Also, it appeared that heavy utilization of 2,4-D was causing widespread damage to non-target plants and, consequently, prime aquatic habitat. This phenomenon could not clearly be explained to everyone's satisfaction through the normal channels of telephone calls and memos and it was decided to enlist the help of the University of Florida (UF). Subsequent research and the sharing of information at a series of gatherings quickly led everyone involved to realize the benefits that could be gained through regular meetings and more open communication. In addition, herbicide choices and application techniques could be altered to create a better fit for the overall management goal of the system.

In 1986, a working group was formed to facilitate the exchange of information between the agencies responsible for management of the lakes and to ensure that each stakeholder had an opportunity to provide input related to floating plant and hydrilla management. As the group continued to meet, it quickly became clear that the means to achieve the differing objectives of each agency was possible as long as each agency was willing to provide information and was willing to accept that other stakeholders might hold different, but valid, goals for the waterway system.

For more than a few years, the biggest concerns were floating plant control and the management of small patches of hydrilla that were beginning to appear throughout the chain. In 1971 and 1979, GFC implemented drawdowns of Lake Tohopekaliga with the goal of improving fisheries habitat. The water levels in the lakes were brought to levels that closely approximated historical low elevations and exposed sediments were allowed to consolidate and oxidize. When the lake refilled, fish populations and fishing success were dramatically improved. In 1987, however, GFC proposed a drawdown that included the physical removal of organic detritus and sediments while the water level was low. As difficult as it was to plan and complete the previous drawdowns, a project of this scope could not have been implemented without input, planning, and cooperation from each agency as well as the Florida Department of Environmental Regulation. Additionally, the strong alliance between the agencies helped to galvanize support from local fish camps and sportfishing guides. The majority of the public was able to understand that a short-term loss of income and access to the lake would result in a greater long-term benefit. The results of the drawdown exceeded fisheries expectations and the public users have supported subsequent drawdowns on Lakes Kissimmee, Jackson, East Lake Tohopekaliga, and the entire Alligator Chain of Lakes.

At about the same time, hydrilla was beginning to expand throughout the chain of lakes. Lake Kissimmee had 4000 acres of hydrilla (~10% coverage) as early as 1987. Hydrilla coverage peaked at 18,250 acres (>50% coverage) in 1995. Lake Hatchineha went from 70 acres of hydrilla in 1986 to 6000 acres (98% coverage) in 1991. From 1987 to 1999, Lake Cypress went from 4 acres of hydrilla to 3700 acres (90% coverage). Lake Toho peaked at 15,000 acres of hydrilla (~85% coverage) in 1994. Fluridone received a full aquatic registration in 1986 and it was anticipated that large-scale fluridone treatments would soon become a reality in most, if not all, of these lakes. As it turns out, the first such treatment occurred on Lake Toho in 1993. But a lot of preparation occurred in that interim period that would not have been possible without a cohesive working group.

Because the water levels are artificially manipulated in the KCOL, it was decided that lowering them as much as possible prior to fluridone treatments would increase the efficacy of the treatments, reduce the amount of herbicide needed to achieve the desired concentration, and reduce the likelihood of losing the herbicide downstream in the event of significant rainfall – an all too common occurrence in central Florida. It's not an exaggeration to say that it almost takes an act of congress to modify the water regulation schedules used by the Corps and

SFWMD. A proposal must be sent to the Corps months prior to any planned treatments. Local agency representatives would draft a modified schedule and submit their request. More often than not, these requests were ultimately granted because of the consensus that had been created in the working group and because there was little to no dissent from any of the stakeholders. Millions of dollars were saved and thousands more acres of hydrilla were controlled in the chain because there was almost no threat of treatment failure due to environmental factors. Also, the anglers and other lake users were made aware of these plans early on and were able to modify their activities appropriately.

One of the most important benefits of a well-organized group such as this is the appearance of a unified front when dealing with the public. No one will claim that every interagency meeting is free from dissent and argument – but by the time we are finished with discussions and plans, everyone is in agreement and is prepared to support the group decision. This became very important when we began implementing the large-scale fluridone treatments in 1993. At the time, many anglers had very negative opinions about aquatic plant management in general and hydrilla management in particular. Floating plants were under maintenance control by this time and research by GFC biologists had dispelled the myths that herbicides caused sport fish to flee from treated areas (Sweatman et al., 1993). But it was still commonly thought that large-scale hydrilla control would ruin the fishing in any given lake. There were many meetings with both large and small groups of anglers to explain the goals of these treatments as well as articles in a variety of media. A unified message from each member of the interagency group went a long way in dispelling uneducated assumptions. Today, a representative of the Bass Anglers Sportsman Society (BASS) is part of our working group to facilitate the exchange of information and angler concerns. Anglers are not the only recreational users of the KCOL. There is also a representative from the United Waterfowlers of Florida who serves as a liaison to the duck-hunting community.

As time passes, lake managers face new and improved challenges almost every day. The managers responsible for the KCOL have had more than their fair share in recent times. The Everglades snail kite began to use the KCOL area in the 1980s when droughts began to impact their habitat around Lake Okeechobee and in the Everglades. Currently, the northern portions of Lake Toho produce more snail kites than any other region in Florida. To say that the presence of an endangered species has altered our operations is an understatement. Current members of the interagency group now include representatives of the U.S. Fish and Wildlife Service and research staff from UF and the University of West Florida. Research subjects on the KCOL include snail kites, apple snails, and their habitats. Protection of these animals is a factor that cannot be underestimated. New stakeholders in the KCOL are making themselves known and we have done our best to incorporate those groups into our meetings to ensure that accurate information is being disseminated to the general public and to ensure that we are aware of any potential conflicts that lake management activities may create with lake users.

More recently, the issue of fluridone-tolerant hydrilla has caused a dramatic shift in the methods used for hydrilla management. As research continues into alternate herbicides for hydrilla control, lake managers are faced with hard choices in order to effectively utilize funding, maximize hydrilla control, and encourage the recovery and expansion of native aquatic vegetation. The group was already working well together and it was a natural progression to tackle this matter without breaking stride.

Over the years, this group of resource managers, applicators, environmental regulators, researchers, and recreational users has expanded and contracted as circumstances warrant. Agencies have merged and divided and new ones have been created. The group that was initially created in order to avoid conflict between resource managers has flourished during adversity because its members have been able to remain flexible and compromise. It is a group that is able to see the long-term goals of lake management and stay on track as circumstances change. People ask what the secret ingredient is that makes things work so well in the KCOL. The answer is that there is no one ingredient that makes it work. It's the willingness to put the benefit of a natural resource in front of everything else. And it's worked for 20 years.

References

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Editorial *continued from page 3*

that both bass and black crappies are back, Lake Apopka will no longer be thought of as a "dead" lake. Black crappie anglers, who often provide more fishing dollars to communities than bass fishermen, would return to Lake Apopka and generate another multimillion-dollar fishery. Fishing also inspires people to take part in other eco-tourism activities such as boating and bird watching from boats. Both activities would enhance the economic vitality of the local communities. With correct decisions, the great recreational potential of Lake Apopka can now be reestablished within a few years.

Introduction

Prior to 1947, Lake Apopka was renowned as a premier largemouth bass fishing lake (Dequine 1950). The lake supported 13 fish camps and had a fishery valued at $1,000,000 per year ($8.7 million in 2005 dollars). Lake Apopka was covered extensively with dense growths of aquatic macrophytes with about 80% of the lake being covered with Illinois pondweed *Potamogeton illinoensis*, and eelgrass *Vallisneria Americana* and boats moved in defined trails. By 1950, Lake Apopka had changed from a macrophyte-dominated lake to a phytoplankton-dominated lake. The cause of the switch to a long-term algal state have been the fodder for many scientific debates but by 1960 the extensive macrophyte community and the largemouth bass fishery became functionally nonexistent in Lake Apopka (Johnson and Crumpton 1998).

Concerns regarding the current status of Lake Apopka's largemouth bass population and aquatic macrophyte community prompted us to conduct a study to assess the abundance of largemouth bass and aquatic plants in the lake (see Murphy 2005). Largemouth bass were sampled by electrofishing near-shore areas of the lake on three occasions, from June through August, 2004. The catch per unit effort (CPUE, number/hr or kg/hr) of largemouth bass was compared and tested with the catch rate of a previous study by Johnson and Crumpton (1998). The aquatic macrophyte community was sampled on 1 October 2004. The widths (m) of the floating-leaved and emergent plant zones were estimated, and the presence of submersed aquatic plants in the open area of the lake was also assessed using a fathometer.

Submersed macrophyte beds, primarily eelgrass, were sampled by recording their area (m^2), density (%), maximum depth (m) of growth, and type soil (sand, or some degree of silt/mud). Eelgrass was focused on during this study because it is the only submersed macrophyte species of significant abundance (~ 1 ha) in the lake besides hydrilla (*Hydrilla verticillata*, ≤ 0.5 ha). Light attenuation was measured in the center of the lake and photometer measurements were used to determine the theoretical maximum depth of colonization (MDC) of submersed aquatic macrophytes in Lake Apopka (or the depth corresponding to 1% of surface irradiance, Dennison 1987).

The lake-wide, largemouth bass, electrofishing catch rate in 2004 was

6.9 fish/hr. Comparison with the combined largemouth bass catch rate in 1989 – 1993 of 6.5 fish/hr indicates that the largemouth bass population has not significantly increased over the last decade ($p \geq 0.05$). The largemouth bass catch rate in Lake Apopka continues to be lower than in other Florida lakes. The relationship between largemouth bass and trophic state in Florida lakes is positive (Bachmann et al. 1996) suggesting that eutrophic and hypereutrophic lakes will have a high abundance of largemouth bass. Lake Apopka is a hypereutrophic lake or eutrophic lake depending on the criteria used to classify lake trophic status, but Lake Apopka does not support an abundant bass population like other eutrophic/hypereutrophic Florida lakes. During our electrofishing, largemouth bass of all sizes, however, were captured; suggesting the present water quality of Lake Apopka is sufficient to support bass. The low abundance of bass, therefore, suggests that another environmental factor beside water quality is limiting bass abundance. Based on past observations and studies, the low abundance of quality fish habitat (e.g., macrophyte abundance) is the likely limiting factor (Dibble et al. 1996).

The need to implement additional management activities besides nutrient control to restore Lake Apopka's largemouth bass fishery became more evident during our summer survey of the lake. Submersed, floating-leaved, and emergent macrophytes occupied less than 1% of Lake Apopka's surface area in 2004. Coverage of aquatic macrophytes remains similar to what the lake had after the loss of its macrophytes in 1947 (Clugston 1963). The rooted aquatic vegetation, therefore, clearly has not expanded in the last several decades despite restoration efforts focused on nutrient control. Macrophyte planting programs also have not been very successful. Eelgrass is a plant that is often used in plant restoration programs and is viewed by many Florida scientists as a bell weather of a successful restoration program (Jaggers 1994). It only colonized a total lake bottom area of approximately 900 m^2 in 2004. In 1999, the SJRWMD reported 11,032 m^2 of eelgrass and suggested the abundance of eelgrass was evidence of a successful restoration effort. Unfortunately, eelgrass abundance has drastically declined since it was replanted around the shore in 1998 and 1999. It now occupies only 8% of its 1999 area. With less than 0.001% of Lake Apopka's area colonized by eelgrass, there must be a limiting environmental factor besides light that is preventing eelgrass and probably other rooted submersed aquatic macrophytes from surviving and expanding.

Other factors besides light attenuation by planktonic algae are involved in limiting the expansion of aquatic macrophytes. The depth and fluidity of sediments, and wind resuspension of sediments, are probably the major factors. Because Lake Apopka is a large (12,465 ha), shallow (1.6 m mean depth), and nearly round lake with a long fetch, it has a high capacity to resuspend the bottom sediments and uproot aquatic vegetation (Bachmann et al. 1999). Eelgrass in 2004 was only found at sites having firm sediments and not at any sites with sediments deeper than 0.25 m. From this we can infer that the depth of sediments (1.5 m mean thickness) covering 90% of Lake Apopka's bottom (Schneider and Little 1969) is too thick to allow eelgrass to inhabit those areas.

Clearly, the current Lake Apopka restoration program has not yet been successful in restoring critical bass habitat, the aquatic plant community, or the largemouth bass fishery. There also is no evidence that the current restoration program with its focus on nutrient control will significantly improve the plant community or the largemouth bass fishery any time soon. The SJRWMD has accomplished its charge of reducing nutrients, but it is now obvious that additional management strategies need to be employed to restore the recreational value of Lake Apopka within a reasonable time. We believe the recreational uses (i.e., fishing) can be reestablished within the next decade. However, the political leadership of Florida must recognize that the sole remaining challenge for a successful restoration of Lake Apopka is not nutrient control, but the establishment of sufficient fisheries habitat to support a sustainable largemouth bass fishery.

Like past challenges, time and money as well as clear agency authority will be required to accomplish the necessary tasks to restore Lake Apopka's largemouth bass fishery in a timely and cost-effective manner. It also must be recognized that that the long wind fetch, fluidity of the bottom sediments, and depth of bottom sediments will make the establishment of sufficient fish habitat very difficult without active and deliberate intervention. So, we elaborate four actions that we believe, if implemented, will make Lake Apopka a valuable natural resource, through fishing, for Floridians, rather than an endless money pit. The actions include:

1) **Designation of a Lead Restoration Agency:** The Florida Legislature should designate the Florida Fish and Wildlife Conservation Commission (FWCC) as the lead restoration agency for the next decade and mandate other state agencies including the SJRWMD to fully cooperate with the FWCC in restoring the largemouth bass fishery.

2) **Largemouth Bass Stocking:** The FWCC should immediately institute a largemouth bass stocking program to quickly restore the economic vitality of fishing to local communities. The program shall involve the stocking of adult and advanced fingerling largemouth bass. The stocked advanced largemouth fingerlings will grow rapidly and help sustain the bass fishery for future years while other management strategies are implemented and brought to completion.

3) **Establishment of a Comprehensive Aquatic Plant Management Program**: The primary habitat of interest is the aquatic macrophyte community, and the interest in the macrophyte community must focus on the plants' value to the largemouth bass fishery. Consequently, the Florida Department of Environmental Protection (FLDEP) should, by their legal authority, transfer aquatic plant management authority (with money) for Lake Apopka to the FWCC so that aquatic plant management efforts will prioritize fisheries needs. The FWCC should, therefore, implement a plant management program at Lake Apopka that permits a fluctuation of plant abundance around the 10 to 15% target criterion, with plant control at access points, and permitting no more than 30% plant coverage in Lake Apopka. An opportunity to reestablish aquatic macrophytes now exists with the non-native hydrilla, however, it might be helpful to let hydrilla grow in Lake Apopka. FWCC and anglers recognize hydrilla as an excellent plant for fish in eutrophic and hypereutrophic lakes (Moxley and Langford 1982). Other scientists from outside the FWCC also now question if hydrilla needs to be eliminated from all Florida lakes (Hoyer et al. 2005). Lake Apopka should, therefore, become the test lake to determine if the FWCC can manage hydrilla to the benefit of recreational fishing.

Permitting hydrilla to colonize bottom areas devoid of plants and establishing a 10-15% plant coverage criterion represents a more practical and viable alternative than completely eliminating hydrilla (Hoyer et al. 2005), as an expansion of hydrilla would have positive impact on the largemouth bass fishery, and the revenue generated through fishing would more than offset the cost of plant management. The spread of hydrilla to downstream lakes could be managed by implementing the SJRWMD's hydrilla identification and contact herbicide program in lakes Beauclair and Dora to prevent the spread to other lakes. Hydrilla does not always out compete natives like eelgrass, coontail (*Ceratophyllum demersum*), and Illinois pondweed (*Potamogeton illinoensis*) (Smart 1992). Consequently, hydrilla could be used to encourage native plant growth in Lake Apopka. This proposal, of allowing hydrilla and native aquatic plants to grow behind artificial reefs, is particularly attractive because not much more than the current maintenance control program already being used to control hydrilla in Lake Apopka would be necessary to keep hydrilla in check outside the barriers.

4) **Enhanced Water Level Fluctuation:** Establishing the artificial reef system will require time and money. Water level manipulation is an immediate, relatively low-cost management activity, which could be undertaken to benefit the fishery (Wegener and Williams 1974, Moyer et al. 1995), now that the farmlands have been purchased. However, there are technical problems associated with a drawdown of Lake Apopka including the high cost (of at least $20 million, Lowe et al. 1992). There are also logistic problems associated with the amount of water needed to be moved since Lake Apopka is such a large lake. The FWCC and SJRWMD, however, could enhance water level fluctuation in Lake Apopka by temporarily flooding the former farmlands that are now being converted to wetlands. Again, this would be an immediate and relatively low-cost management strategy for restoring a multimillion-dollar largemouth bass fishery at Lake Apopka.

To obtain this article in its entirety or to send comments to the authors, please contact Stephen J. Murphy, Mark V. Hoyer, or Daniel E. Canfield Jr at the, Department of Fisheries and Aquatic Sciences, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, Florida. 32653.

AQUAVINE

The **2006 Aquatic Weed Control Short Course** will be held **May 1-5, 2006,** at the Coral Springs Marriott Hotel, Golf Club, and Convention Center in Coral Springs, Florida. See the main web site (http://conference.ifas.ufl.edu/aw) for the tentative agenda, a listing of the 2005 sponsors, 2006 sponsorship information, certification examination & CEU information, specialized training & sessions, registration, accommodation, and travel information. Following is the link for your convenience. Register anytime before March 20, 2006 to receive the early reduced registration fee of only $200. After that date the regular registration fee is $250. Students may register for only $100 (Student attendees must fax a copy of their Student ID to Office of Conferences and Institutes at: 352-392-9734 to complete registration)

Student Paper Contest

The Aquatic Plant Management Society is soliciting **student papers** for their upcoming 46th Annual Meeting to be held **July 16-19, 2006,** at the Portland Marriott Downtown Waterfront Hotel in Portland, Oregon. Oral and Poster Presentations of original research on the biology or ecology of aquatic and wetland plants, control methods (biological, chemical, cultural, mechanical) for invasive exotic or nuisance native plant species, and restoration projects involving wetland or aquatic plants are solicited.

The Society encourages students that have conducted original research to present their findings and gain a valuable perspective on aquatic plant problems and various management applications throughout the U.S. The meeting locale in Portland provides and excellent opportunity for students from Pacific Northwest in particular to attend and present research on aquatic plant management in this region.

The APMS has a strong ethic of student support and all qualified attendees will be provided room accommodations (based on double occupancy) and waiver of registration fees. In addition, 1st, 2nd, and 3rd place prize money will be awarded in separate contests for both oral and poster presentations. For more information about the contest, please contact: Dr. Mark A. Heilman, SePRO Research and Technology Campus, 16013 Watson Farm Seed Road.Whitakers, NC 27891, E-mail: markh@sepro.com, Phone: (252) 437-3282 x223

FAPMS Scholarships Available

The Florida Plant Management Society Scholarship and Research Foundation Inc.

Announces the availability of the following scholarships.

- **PAUL C. MYERS APPLICATOR DEPENDENT SCHOLARSHIP** – Provides up to a $1,500 scholarship to deserving dependents of

FAPMS members. Submission deadline: June 1, 2006

- **WILLIAM L. MAIER JR.: MEMORIAL SCHOLARSHIP** - Provides up to $1,000 to a deserving student that meets a series of eligibility requirements. Submission deadline: August 1, 2006.

To apply for the above scholarships please contact Don Doggett, PO Box 60005, Ft. Myers, FL 33906 (239) 694-2174. If requesting an application please specify as to which scholarship you are applying.

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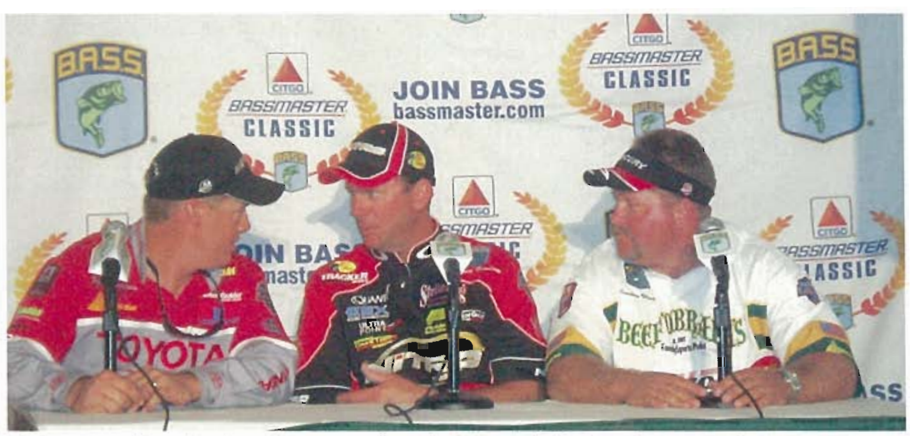
Bassmaster Classic Angler Interviews

This year marked the first time that the Bass Anglers Sportsman's Society (BASS) held their championship fishing tournament, "Bassmaster Classic", in Florida. As editor I took advantage of the media events to interview top professional bass anglers on their thoughts about aquatic plant management.

Overall, I'd have to say that 80% of the pros liked what they saw with aquatic plant management in the US and were complementary of the State of Florida's work on the Kissimmee Chain of Lakes where the tournament was held. Most of the professional anglers understood Florida's need for higher plant management due to the semi-tropical nature of our state. I was able to offer some educational facts to a few misguided pro anglers that thought that lack of management would solve problems "naturally, without all those poisons". I even challenged several unsatisfied anglers by giving them some brief information about plant biology and growth, then listed the limited tools and multiple user demands, and finally asked them how they would envision managing that situation. After getting many of the anglers to "walk in the shoes of an aquatic plant manager", they agreed that the task of keeping the plants under control and making all the user groups satisfied is a very difficult one at best.

During the interview process I was able to identify educational needs for plant managers in each state and I feel the need to challenge aquatic plant managers to improve the way they are distributing their educational materials to user groups. Whether we like it or not, these professional anglers are speaking to the media on our behalf and listing the successes and failures of proper aquatic plant management in the public lakes they visit each year. Aquatic plant management can define a bass fishery and getting this user group's input could go along way to enhancing aquatic plant management programs in the US. We have the support of most of the professional bass anglers but still need to make up some ground throughout the US. Look for an article summarizing the details of the interviews in the next issue of *Aquatics* magazine. *Editor*



Interview of professional bass anglers (left to right) Terry Scroggins (FL), Kevin Van Dam (MI), and Preston Clark (FL) on their knowledge and opinions of aquatic plant management.

Calendar of Events

March 27-29 2006: 25th Annual Western Aquatic Plant Management Society Meeting, San Diego, CA. www.wapms.org

May 14-19, 2006: 14th International Conference on Aquatic Invasive Species, Key Biscayne, FL, www.icais.org/

July 16-19 2006: Aquatic Plant Management Society (AMPS) 46th Annual Meeting. Portland, OR. www.apms.org

April 19-21, 2006: Florida Vegetation Management Association Annual Meeting. Daytona Beach, Fl. www.fvma.info/conference.html

April 24-26, 2006: Florida Exotic Pest Plant Council Annual Meeting, Gainesville, FL. www.fleppc.org

May 1-5, 2006: UF-IFAS Aquatic Weed Control Short Course. Coral Springs, FL http://conference.ifas.ufl.edu/aw/

May 18-21, 2006: Florida Native Plant Society (FNPS) Annual Conference. Daytona Beach, FL. www.fnps.org

June 5-8, 2006: Florida Lake Management Society (FLMS) Annual Meeting. St. Augustine, FL. www.flms.net

October 30-Nov 2, 2006: Florida Aquatic Plant Management Society's 30th Annual Conference. St. Petersburg, FL www.fapms.org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