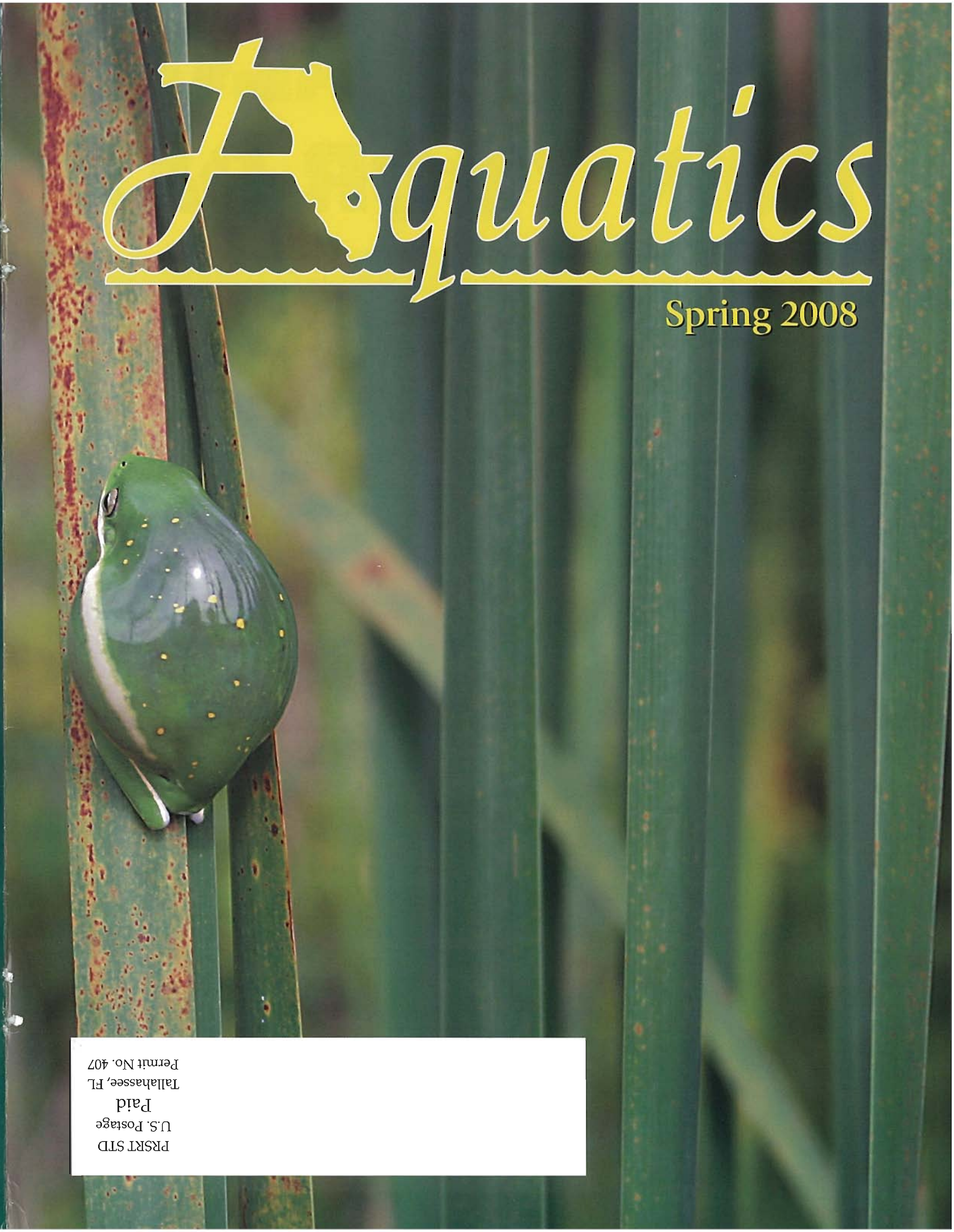
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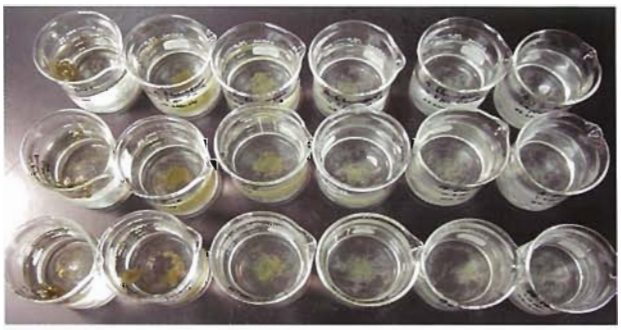

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A tree frog taking advantage of habitat offered by a stand of Cattails (Typha sp.) located on South Lake, White Springs, FL. Photograph by David Tarver.

Aquatics

Spring 2008 / Vol. 30, No. 1

Contents

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Progress of *Hydrilla* Eradication Clear Lake, CA[1]

Dr. Robert Leavitt[1], Dr. Patrick Akers, Dr. Tyler Koschnick, and Mr. Scott Shuler[2]

Alarms went off in her head as Robin Breckenridge pulled hydrilla (*Hydrilla verticillata* (L.f.) Royle) from Clear Lake on August 1, 1994. There was not supposed to be any in Clear Lake. Robin is a weed biologist for the California Department of Food and Agriculture (CDFA) and she was on a routine aquatic weed survey with Lake County biologist, Chris Twohy. Robin said, "Chris and I could see the mat of hydrilla floating from several hundred feet away and knew immediately that we had a major new infestation. We took several samples and rushed them back to the Lake County Office where they confirmed with Agricultural Commissioner Mark Lockhart that this was a probable hydrilla find." They placed samples in an ice chest and Robin hurried them to Sacramento for confirmation at CDFA's Botany Lab. Robin said, "By the time I reached CDFA Headquarters in Sacramento, the building was packed with Division staff, biologists, taxonomists, and local news reporters. Samples were confirmed as hydrilla, and I returned to Clear Lake to begin a delimitation survey of the infestation. By the end of the first week, there were ten boats with biologists from CDFA, Lake County, the California Department of Fish and Game, and Lake County Sheriff's Boat Patrol, all surveying and mapping Clear Lake sites."

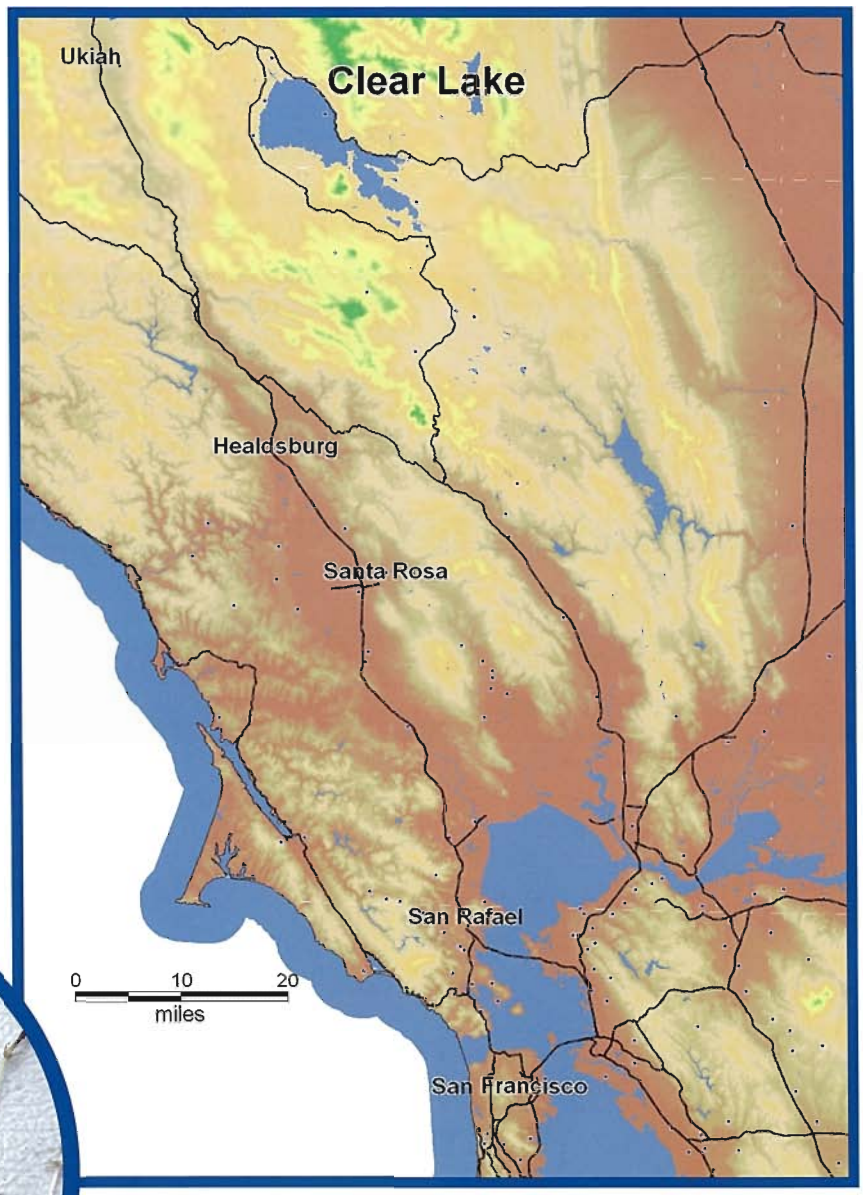

Figure 1. Clear Lake, CA.

Figure 2. Hydrilla sprouting from tubers.

Within two weeks, the CDFA had proclaimed an emergency project and made the first copper herbicide treatment to the lake to control hydrilla. The Project's goals included

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eradicating the hydrilla, maintaining the quality of the fishery and environment, and keeping the public informed about the effort.

Clear Lake is in Lake County, about a two-hour drive north of San Francisco (Figure 1). It is the largest natural, freshwater lake completely within California's borders, with 43,000 acres and over 100 miles of shoreline. It is a shallow, productive (eutrophic) lake, averaging 26 feet deep. It is so productive that it has been called the "Bass Capital of the West".

Clear Lake will host a predicted 108 fishing tournaments in 2007, and it is a prime destination for all kinds of water activities. Recreation around the lake plays a major role in the economy of the area. Tourists spent an estimated $140 million there in 2003, which supported 2,800 jobs (Dean Runyan Associates 2007). The water from Clear Lake flows down Cache Creek into Yolo County where it is used for irrigation. Cache Creek connects with the Sacramento River through the Yolo Bypass.

Hydrilla in California

Hydrilla has been called "The Perfect Aquatic Weed" (Langeland 1996). Hydrilla can clog waterways, dams, and hydroelectric intakes. It often interferes with boating and can harm fish and wildlife. Hydrilla produces small potato-like subterranean turions (hereinafter referred to as tubers) in the sediments (Figure 2). The tubers can survive for a minimum of four years (Van and Steward 1990), and hydrilla can produce greater than 30 million tubers per acre under experimental conditions (Steward and Van 1987) and up to five million per acre under field conditions (Harlan et al. 1985). To make matters worse, the tubers are beyond the reach of approved aquatic herbicides.

When Robin found hydrilla in Clear Lake, the CDFA had already been eradicating it in California for 18 years. The first eradication project began in the Imperial Irrigation District (IID) in the mid 1970's, where it infested 600 miles of canals at the peak. Hydrilla clogged the irrigation canals and reduced water movement up to 90 percent. The CDFA, the United States Department of Agriculture (USDA), and the IID built a hatchery to raise sterile (triploid) grass carp in the mid 1980's. Hydrilla is a favorite food for grass carp. The combination of carp, judicious herbicide use, and concrete lining of many canals reduced hydrilla in the IID from a major problem to a minor nuisance. There is no more hydrilla in the main water delivery system.

In total, the CDFA has eradicated hydrilla from 19 sites. These have ranged from very small sites to 160-acre Lake Murray in San Diego County. The CDFA is currently fighting hydrilla in ten locations. Eradicating hydrilla is of prime importance in a state that moves a lot of water for agriculture, industry, and cities.

The Clear Lake Project

In Clear Lake, a copper herbicide (Komeen®) was the main treatment until fluridone (Sonar®) was registered for use in California in 1996. Fluridone has negligible risks to fish and wildlife, it is of very low mammalian toxicity, and it is very effective on hydrilla at relatively low use rates (ppb). As a result, the CDFA has used fluridone as the product of choice ever since. In particular, the CDFA has used the slow release pellet (Sonar SRP®) for more than 95 percent of its fluridone use. CDFA biologists have also done a small amount of diving to remove hydrilla plants in Clear Lake. Diving is limited because digging out the plants churns up the sediments, and there are restrictions on activities that dis-

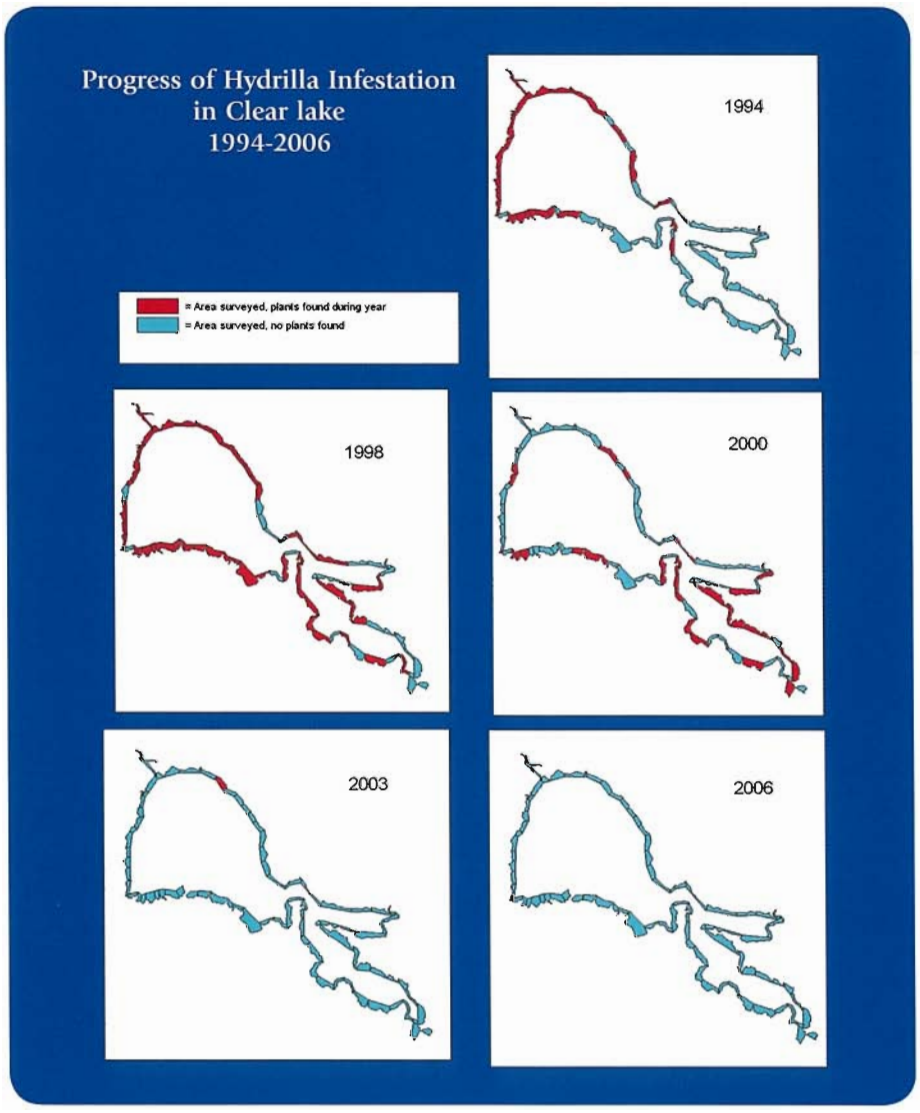

Figure 3. Location of hydrilla management units (86) in Clear Lake, CA and year of first Hydrilla detection.


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turb the bottom. In addition, diving is limited because the lake, despite its name, has very poor visibility.

As the Project progressed, the hydrilla situation in Clear Lake looked like it was getting worse in some ways before it started getting better (Figure 3). Hydrilla covered an estimated 425 acres when it was first discovered in 1994. Most of that area was heavily infested with many solid patches. Over the first couple of years, the treatments decreased the density of the plants, but the extent of the treated areas grew as the Project crew found previously missed spots and plant fragments started new populations. Whenever the Project finds a new spot of hydrilla, the crew treats a minimum of five acres around the find, even if it is a single plant. This tactic helps make sure that any undetected plants near the find are also treated, and it helps concentrate enough herbicide in the area to be effective despite any water movements. Every area also receives treatments for at least three years *after* the *last* find in the area, to try to wear out that long-lived tuber bank (three-year rule).

As a result of the increasing number of separate spots with hydrilla, and because of the eradication strategies, the total size of the treated area increased steadily until it peaked at 1,440 acres in 2002. On the other hand, the number of actual recoveries of hydrilla decreased steadily during this time. By 2000, the project crews recovered hydrilla only 67 times, including surveys in treated areas. Many of those finds were small fragments of herbicide-damaged plants. By 2003, there was only one find, even though 1,256 acres still received treatment because of the three-year rule. The Project crew found no hydrilla in 2004 and 2005, as the treated area continued to decline.

In 2006, all treatments ended and the Project began the wait to see how much hydrilla would re-infest from the tuber bank following three years of no finds. There was suspicion that the use of fluridone was masking the size of the remaining population by killing off small plants as they emerged from tubers in the sediment, before they could grow big enough to be found. So it would take some time to determine the status of the infestation. The 2006 season passed without finding any hydrilla. The Project increased the crew size for the 2007 season, to intensify the survey. Then, on July 9, hydrilla appeared, the first plant in over four years. Treatments resumed the next day.

As of late August, the crew had found about 28 separate spots of hydrilla, concentrated in four areas. If all the plants found so far were put together, they would probably not cover an area 50 feet across. Most of the finds have been single plants; the largest has been a patch about six feet across. All the new spots are under management. At the current rate of finding plants, the CDFA expects to treat less than 200 acres in Clear Lake in 2007, less than one-half percent of the lake. Everyone involved with the Project would have loved to have the hydrilla completely eradicated. Still, we were betting some plants would come back, and the crew was ready and waiting for them. The remaining quantity of plants is a vast decrease from the initial 425 acres, but there is still work to do.

The CDFA has learned a lot in its long fight against hydrilla. Robin says, "We were very lucky to have found the hydrilla while it was still a relatively small infestation in Clear Lake and had immediate help from a wide group of state and county agencies. We were able to mobilize and begin delimitation and chemical treatment almost immediately following confirmation. We continue to survey all recreational lakes and waterways within 50 miles of this infestation on an annual basis, and have learned from long years of experience that repeated aquatic surveys are essential in the fight against this major aquatic pest."

The Keys to Eradication

Several keys to a successful eradication program stand out, including: a) finding a new infestation when it is small, b) ensuring a rapid response, and c) providing long-term follow up.

Early detection is critical because the chances for eradication fall rapidly as the size of the infestation increases. The costs also increase rapidly. Also, with aquatic plants, it is important to find them before they can spread downstream to critical areas, such as the Sacramento-San Joaquin River Delta. To make early detection a reality, the CDFA routinely looks for hydrilla in all the high-risk waterways of California.

Rapid response is important because new infestations need to be controlled before they can spread, and, in the case of hydrilla, before a large tuber bank can form. The CDFA tailors the response to the situation. Sometimes we use aquatic herbicide, sometimes dredging, sometimes drawdown and fumigation. The CDFA does not allow mechanical harvesting in open water such as Clear Lake because harvesters create hydrilla fragments, which float and start new infestations. To make rapid response a reality, the CDFA has authority and funding to eradicate hydrilla wherever it is found in the state. The CDFA also has great support from federal, state, and county agencies.

The third key to a successful eradication program is long-term follow up. This is especially important with a weed like hydrilla that produces a long-lived tuber bank. In Clear Lake, the Project crew is finding plants after not finding any for four years, a year after all herbicide treatments were stopped. Those plants are almost certainly sprouting from tubers. Successful follow-up depends on having managers who understand the long-term nature of hydrilla eradication and who make funds available even in years that appear to be hydrilla-free. Again, the CDFA has great support from federal, state, and county agencies.

The CDFA has a policy to monitor all emergency projects for environmental safety, and the hydrilla projects have been no exception. In Clear Lake, the CDFA monitored the water for copper in 1996 and 1997, and has monitored fluridone almost every year since 1996. The water monitoring became more "official" with the advent of the

NPDES permit requirements in the Western U.S. (9th Circuit) in 2001, and has continued even though that permit may no longer be strictly required. At no time has the monitoring ever indicated a threat to Clear Lake's fishery, urban use of the water, or down-stream agricultural use of the water.

"Clear Lake deserves to be No. 1 bass lake in the country"

The Clear Lake Hydrilla Eradication Project clearly has never hurt the popularity of Clear Lake or the fishing experience. Recently, Terry Knight of the Lake County Record Bee in "The Outdoorsman" wrote about bass fishing in the lake. During a recent Bassmaster tournament, the winner had a four-day catch weight of 122 pounds, 14 ounces, blowing away previous Bassmaster and FLW-Outdoors records (FLW-Outdoors record: 93 pounds, 5 ounces). Knight wrote, "What does the latest record mean for Lake County and Clear Lake? First, it puts Clear Lake on the map as far as a bass fishing destination is concerned. ESPN rated Clear Lake as the No. 2 favorite bass lake in the world a year ago, just behind Lake Amistad in Texas, but that has all changed with just one tournament." During a tournament, the competitors typically land five to ten bass a day weighing over eight pounds each. Knight attributes the success to an abundance of baitfish, crayfish, etc., warm weather causing bass to move to shallower water to spawn, and improved water clarity. Clearly, the lack of hydrilla and the judicious use of herbicides have never impaired the quality of this lake or people's enjoyment of it.

Summary

So what does Robin say about all of this 13 years later? Reflecting on the progress of the hydrilla eradication in Clear Lake, she sums the program up with these words: "We have had amazing success with our hydrilla eradication efforts at Clear Lake considering the size of the lake and its diversity. We have been able to successfully control hydrilla while maintaining all public recreational, fisheries and irrigation uses. I believe that we have had much of our success because we have maintained open communication and an information network with local residents, fishermen, and recreational enthusiasts, from the first day hydrilla was found infesting the Lake in 1994 to the present."

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State Updates on Aquatic Plant Management Activities: North Carolina and Vermont

Michael D. Netherland
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Introduction

In this issue we provide aquatic plant management updates from the states of North Carolina and Vermont. We have previously received updates from Idaho, Minnesota, and Maine (Fall 2007 Aquatics), and Washington, Wisconsin, and Mississippi (Winter 2007 Aquatics). Following these recent publications there has been a confirmation of an established population of hydrilla (*Hydrilla verticillata*) in an Idaho river, and an established population of egeria (*Egeria densa*) in a Minneapolis, MN Lake. These finds illustrate the potential for invasive plant introductions to come from unexpected sources. While it might be logical to assume that the source of Idaho's hydrilla would be from the sparse monoecious hydrilla populations that have been under eradication programs in neighboring Washington state (see Winter 2007 issue of Aquatics), the hydrilla found is Idaho is of the dioecious biotype. The closest known populations of dioecious hydrilla would be states such as California and Texas. The actual source of the Idaho introduction may never be found, and it is just as likely these plants could have come from Florida versus Texas. At a minimum, it is safe to assume this dioecious hydrilla traveled a long distance prior to arriving in Idaho. Likewise, the find of egeria in the middle of a metropolitan lake in Minneapolis challenges the traditional view that this plant would not thrive in the colder climates of the north. With no nearby populations of egeria, this find also challenges our view that invasive aquatic plants are typically spread from site to site by boat traffic. This pattern of invasive plants "showing up" and thriving

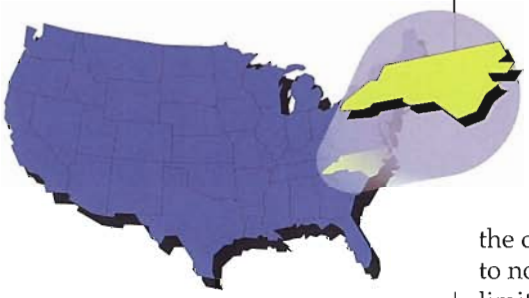
in unexpected places is likely to increase in future years, and it is important for resource managers and researchers to educate people about the need for proper plant identification within and outside of the field of aquatic plant management. These state updates are one way of providing information on some of these new invasive plant introductions.

In February, I spoke at a workshop entitled "Knocking at the Door: An Aquatic Invasive Species Workshop" in Milwaukee, WI. With an 8:00 A.M. Saturday morning start, and a temperature of 4 degrees; I had my doubts about the attendance. I was pleasantly surprised to see over 180 people coming to learn about hydrilla. Given the prior experience with Eurasian watermilfoil in northern lakes, the potential spread for spread of hydrilla is taken quite seriously in this region. While there are still some questions regarding the invasive nature of hydrilla in the northern tier states, prior experience with hydrilla in the south would suggest that early detection and rapid response programs are the most prudent course of action at this time.

With the update from Rob Richardson (Part I) at North Carolina State University (NCSU), we see that North Carolina "has it all", at least from an invasive aquatic plant perspective. The climate and topography of the state creates habitat for invasive species characteristic of both the northern tier and southern tier states. The commitment to battling invasive aquatic species in North Carolina is highlighted by the recent decision to fill an academic position at NCSU dedicated to research of aquatic and invasive plants. Seeing new graduate students from North Carolina with a focus on aquatic plant management is a welcome site at the national and regional aquatic plant management meetings. In addition to activities at NCSU, the state aquatic plant management program is described by Rob Emmons in part II. With a combination of herbicides, grass carp, and traditional biological control, the state of North Carolina is active in funding projects for control of hydrilla and alligatorweed. Projects to eradicate giant salvinia from North Carolina waters are also described.

Ann Bove provides a nice summary of the history of invasive plants and the subsequent establishment of the Aquatic Nuisance Control Program in Vermont. Water chestnut and Eurasian watermilfoil continue to be the main problem plants, and the state follows an integrated management approach and generally requires that long-term management plans be drafted. The state's

approach to mechanically harvesting water chestnut on 40 miles of Lake Champlain provides a good example of the benefits of sticking with a strategy for long-term benefits. The state's use of citizen volunteers (Vermont Invasive Patrollers) is a good example of educating the public to be on the lookout for existing invasives as well as potential new introductions.



North Carolina Part I Overview and Research

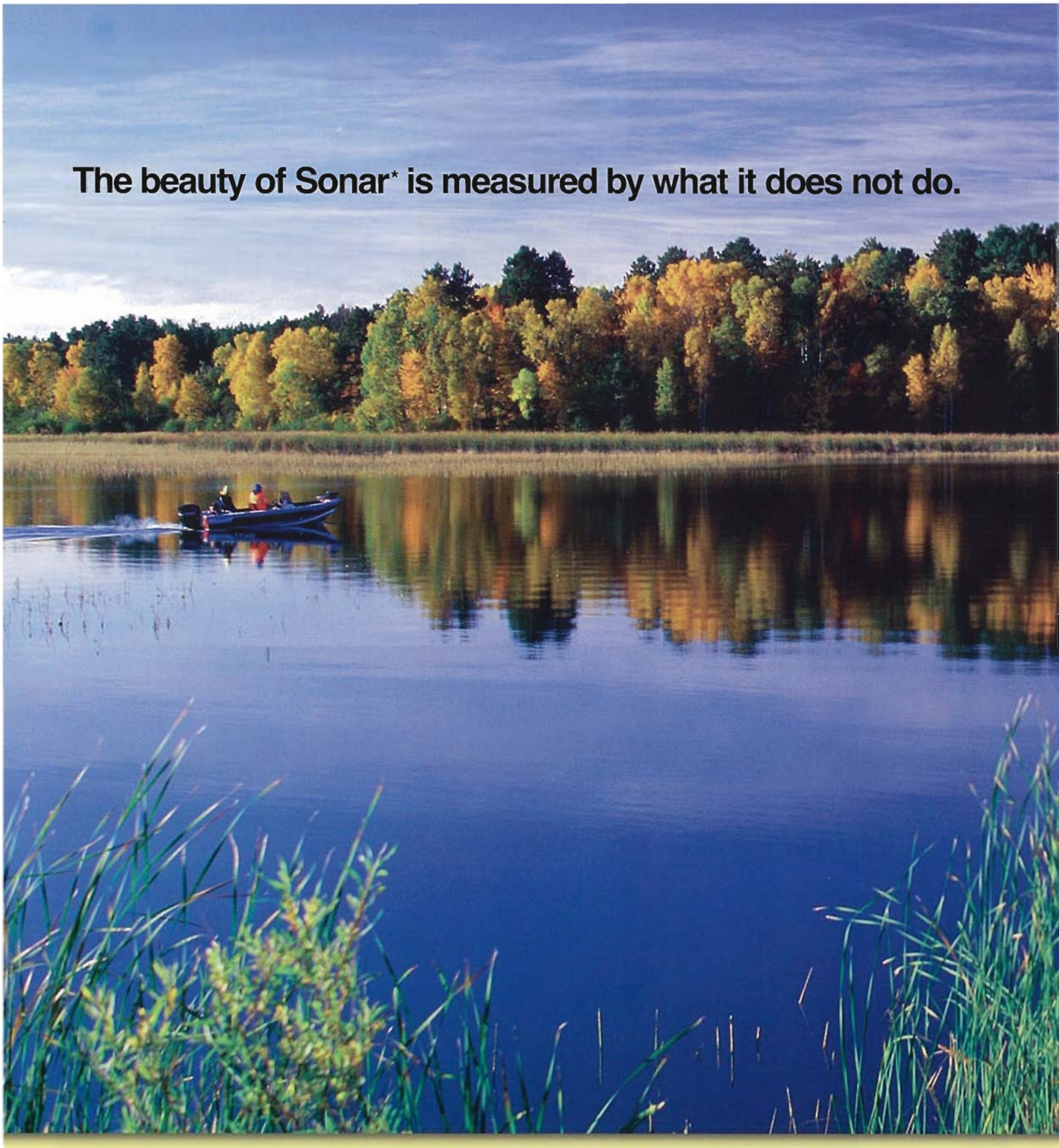
Rob Richardson
Assistant Professor and Extension Specialist
North Carolina State University

North Carolina has three distinct geographical regions, which provide a wide variety of environments for aquatic invasive plants to establish. As a result, numerous aquatic plant species are common and troublesome in the state. As shown in Table 1, the most common species in North Carolina are not always the most troublesome. More money is spent on hydrilla management each year than other species, although the acres infested with hydrilla are less than many other species. Parrotfeather (*Myriophyllum sp.*)and Common Waterweed (*Egeria densa*) are two of the most geographically diverse species and can be found infesting high elevation sites in the mountains to low elevation and much warmer sites in the coastal plain. It is also interesting to note that watermeal is typically limited to small ponds in the piedmont region of North Carolina, but probably infests the greatest number of sites of all aquatic plant species in the state. As a result, watermeal constitutes the largest number of aquatic weed management calls and inquiries each year.

Aquatic weeds also continue to spread in North Carolina. Lyngbya (alga) is one of the more rapidly spreading problems in large water bodies while hydrilla continues to creep from reservoir to reservoir. Yellow floating heart is occasionally introduced from the water garden trade and is very difficult to control once established. Other aquatic weeds spreading within the state include Alligatorweed, Creeping Water primrose, Parrotfeather, Phragmites, *Egeria densa*, and Waterhyacinth.

Two North Carolina eradication programs are currently underway for aquatic weed species. The most notable one is the giant salvinia eradication program led by the North Carolina Giant Salvinia Task Force. Giant salvinia was introduced into North Carolina as a contaminant in the aquatic nursery trade. At one time, giant salvinia infested a high of around 40 acres on 10 sites. The eradication program has successfully reduced the infestation to approximately two acres on a single site. The second eradication program is being conducted by the North Carolina Department of Agriculture for purple loosestrife. This program has also been relatively successful in limiting loosestrife to small infestations of individual plants. Both eradication programs will continue in the near future.

The beauty of Sonar* is measured by what it does not do.



A beautiful lake can turn ugly once invasive aquatic weeds like hydrilla or Eurasian watermilfoil take over. But before you introduce non-selective grass carp or launch a mechanical harvesting program, consider what Sonar Aquatic Herbicide does not do.

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Restores Aquatic Habitats

Lake Gaston represents the largest single management effort for aquatic weeds species in North Carolina. This 20,000-acre impoundment on the North Carolina-Virginia border is utilized for domestic drinking water, fishing, power generation, and recreation. It is also the main economic driving force for the surrounding area. Lake Gaston is currently infested with monoecious hydrilla, *Egeria densa*, Eurasian watermilfoil, brittle naiad, and Lyngbya. Hydrilla infestations have been as high as 3,800A in the lake with infestations of the other species in the tens to hundreds of acres. To deal with this complex assemblage of species, an integrated weed management plan has been implemented on the lake. This plan includes a triploid grass carp stocking rate of 10 fish per hydrilla vegetated acre, fluridone treatment of appropriate areas as budget allows, contact herbicide treatment where necessary, release of biocontrol agents, and establishment of native vegetation. The fall 2007 full lake survey by Remetrix® indicated approximately 1,250A of hydrilla, a significant decline from around 3,000A the previous year. Hopefully, decreases in hydrilla acreage will continue.

To address the wide variety of aquatic weed problems present in North Carolina, North Carolina State University has been conducting numerous research efforts each year in cooperation with other entities including aquatic algaecide/herbicide companies, applicators, lake managers, AERF, NC Department of Environment and Natural Resources, NC Wildlife Resources Commission, US Army Corps of Engineers, and others. A small sample of these efforts will be briefly discussed below and contacting Rob Richardson at NCSU can obtain additional information about these and other topics.

Evaluation of new and experimental herbicides. NCSU has conducted multiple research trials over the last few years to evaluate the efficacy of bispyribac, carfentrazone (Stingray®), flumioxazin, imazamox (Clearcast®), Mt, penosulam (Galleon®), and other products on aquatic weeds including alligatorweed, creeping water primrose, duckweed, *Egeria densa*, giant salvinia, hydrilla, parrotfeather, Phragmites, waterhyacinth, watermeal, water lettuce, and others. Results from these trials have been presented at regional and national APMS meetings and will hopefully support registration of these products and improve management programs.

Hydrilla tuber monitoring. In cooperation with the Lake Gaston Weed Control Council and SePRO®, NCSU has been sampling the tuber bank on Lake Gaston and the Tar River Reservoir to determine the impacts of fluridone treatment and

Table 1. ***Most common and most troublesome aquatic weeds in North Carolina (Webster 2007).***

Most Common	Most Troublesome
1. Algae	1. Monoecious hydrilla
2. Duckweed	2. Alligatorweed
3. Cattail	3. Filamentous algae
4. Pondweed spp.	4. Watermeal
5. Naiad spp.	5. Parrotfeather
6. Alligatorweed	6. Phragmites
7. Waterlily species	7. Egeria densa
8. Watermeal	8. Giant salvinia
9. Primrose spp.	9. Primrose spp.
10. Parrotfeather	10. Eurasian/variable-leaf milfoil

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the longevity of monoecious hydrilla tubers. The first year of research indicated that successful management reduced monecious hydrilla tuber numbers by 75% across the two water bodies. If these rates continue over time, at least 4 years would be required to reduce tuber numbers by 99.5%. These monitoring efforts will continue over time to determine if these rates stay uniform, or if depletion rates change due to factors such as tuber cohorts with extended dormancy periods.

Watermeal control. Greenhouse trials and field research in 32 ponds was conducted over the last two years. One of the most important aspects of watermeal research is that herbicidal control in the greenhouse does not necessarily translate to the field. Diquat consistently controls watermeal in greenhouse trials, however, control was not acceptable in six of eight ponds treated under field conditions. Fluridone is still the most consistent product evaluated in pond trials. Penoxsulam and flumioxazin have shown promising results and will be evaluated further under field conditions. Watermeal has not been controlled in pond trials with carfentrazone even though the species is listed as controlled on the Stingray® label (dated 2004).

North Carolina Part II – NCDENR Aquatic Weed Control Program

Rob Emens
Environmental Specialist
North Carolina Department of Environment and Natural Resources

The NC Aquatic Weed Control Program is housed within the DENR-Division of Water Resources and has been operating since 1983. In recent years the Program has been funded by general assembly appropriations at $350,000 annually. Of this, $200,000 is allocated annually to support the control of hydrilla in Lake Gaston.

The Program is operated as a cost-share arrangement whereas local governments match State dollars following a 50:50 formula. The Program is staffed with personnel licensed as aquatic herbicide applicators and equipped with a fleet of boats, spray rigs, etc. The Program staff performs field activities for nearly all projects (site assessments, surveys, herbicide applications, etc.). Large projects are typically contracted because the Program currently has only two positions.

NCDENR officially recognizes specific plants as "noxious aquatic weeds" and maintains a list of these species. A copy of this list has been posted on the AWC Program website, visit www.ncwater.org and click on Aquatic Weed Control. This list was modified in 2006 to include *Eichhornia crassipes, Myriophyllum aquaticum,* and *Pistia stratiotes.*

In 2007, the NC Aquatic Weed Programs largest expenditure was $200,000 in support of 1,565 A of herbicide treatment and 7,720 grass carp for hydrilla management in Lake Gaston. An additional $126,000 was spent for hydrilla management on another 16 sites. Alligatorweed projects constituted $31,000 in expenditures across 35 separate sites. Treatments for alligatorweed are typically glyphosate and/or imazapyr. Miscellaneous projects for other weed species totaled $47,000. In total, the NC Aquatic Weed Program provided cost-share for 45 cooperators across 66 distinct sites.

Historically, hydrilla and alligatorweed have been the most problematic aquatic weeds in North Carolina comprising the major part of the Program's annual workplans. Hydrilla has generally been limited to reservoirs in the piedmont region. Many of these infestations are controlled and eventually eradicated through methodical grass carp stocking programs. Other areas receive herbicide treatments as part of a long-term management strategy.

Alligatorweed is widespread throughout the coastal plain and is problematic in rivers where it tends to form contiguous patches along shorelines for miles and will render them nonnavigable. It also impacts agriculture by growing in fields

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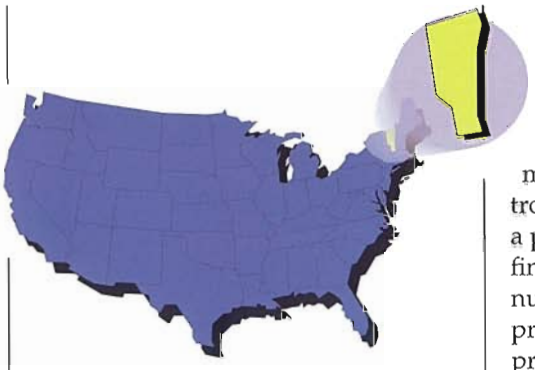
and in drainage systems. Alligatorweed spread and establishment in the piedmont and mountain regions has been thwarted in part by early detections and rapid responses. Nearly all control efforts in NC utilize herbicides as the primary (if not only) component. Alligatorweed flea beetle release trials were performed during the 1990's but were limited by poor over-winter survival. In 2004, 1,500 beetles were released on the Lumber River (Lumberton) and 1,000 released on the New River (Jacksonville) in southeastern North Carolina. With no additional releases, beetles were observed on the Lumbar River in the fall of 2007. While these insects continue to persist and expand their range, significant control is rarely observed until very late each growing season. It is theorized that North Carolina winters will select for beetles with increased cold-tolerance to hopefully provide greater control of alligatorweed in the future.



Aquatic Plant Management in Vermont

Ann Bove
Vermont Agency of Natural Resources
Water Quality Division

Vermont's association with invasive aquatic plants stems back to the 1940s with the confirmation of *Trapa natans* and *Nymphoides peltata* in Lake Champlain, one of the largest freshwater lakes in the United States. *Myriophyllum spicatum* followed in 1962, again first confirmed in Lake Champlain.

In response to these confirmations, in 1977 the Vermont legislature mandated the establishment of an Aquatic Nuisance Control Program, followed in 1978 with a program to provide cost-shared financial assistance for aquatic nuisance species management programs. Funding for the grant program comes from the receipt of 25% of the revenue from Vermont motorboat registrations, all of the revenue from a motorboat registration surcharge initiated in 2004, and in some years, federal funding from the U.S. Army Corps of Engineers and additional state sources.

When the Vermont Aquatic Nuisance Control Program was established in 1977, one biologist was assigned to the Program. *Trapa natans* was well established in southern Lake Champlain, *Myriophyllum spicatum* was identified in three waters, and a handful of other aquatic and wetland invasives had been confirmed somewhere in the state. Animal invasive species like zebra mussels and alewives aside, today *T. natans* is known from 21 waters; *Nymphoides peltata* from 1 water; *Myriophyllum spicatum* from 90 waters; *Hydrocharis morsus-ranae* from 2 waters; *Najas minor* from 2 waters; and *Potamogeton crispus* from 26 waters. *Lythrum salicaria* and *Fallopia japonica* are widespread throughout the state. *Butomus umbellatus*, *Iris pseudocorus* and *Phragmittes australis* are common in the Lake Champlain basin on the western side of the state and in the Connecticut River basin to the east. Since 1994, the Program has been represented by three full-time and one part-time staff. Of the full time staff, one staff person solely administers an aquatic nuisance control permit program, one focuses on administering grants and is the lead on aquatic invasive plants, and one implements spread prevention activities and is the lead on aquatic invasive animals. The part-time staff person oversees statewide management of *T. natans*.

The focus of Vermont's Aquatic

Nuisance (primarily nonnative) Species Program centers around five elements: control and spread prevention projects, administration of the permit and grant programs, public information and education, environmental monitoring, and control technology research. Mitigating the effects of species already in Vermont as well as preventing new plant and animal species from entering are both Program priorities to ensure the integrity of the state's aquatic ecosystems - over 800 lakes and ponds, an estimated 300,000 acres of wetlands and miles of rivers and streams - is protected.

Roughly half of Vermont's 64 lakes/ponds with *Myriophyllum spicatum* and a handful of the 26 other waters with populations are undergoing some type of control action for this species. Almost all of these projects are the result of local initiatives with technical assistance and funding contributions provided by the State. Management typically involves an integrated approach and the development of long term management plans. Controls to date include herbicides, mechanical methods (e.g. traditional harvesting, suction harvesting) or physical methods such as benthic barriers and removal by hand. Use of the watermilfoil weevil, *Euhrychiopsis lecontei*, although not a predictable operational control tool, is stocked in some watermilfoil-infested lakes. All of these management programs involve ongoing surveillance and include educational components. In four previously confirmed *M. spicatum* waters, on-going control efforts have successfully managed the species to the point where it has not been found in a number of years. "Managed" but I hesitate to say "eradicated." With this species still prominent in many of our heavily used recreational lakes and so many Vermont waters with public access, reintroduction is possible.

Of the 21 waters known with *Trapa natans*, populations were eliminated in two, and of the remainder, all are under active management by the Program in partnership with many government and non-government groups and individuals. Management includes mechanical harvesting, removal by hand, on-going surveillance and public education. Over the last decade, a commitment of annual funds combined with a strong regional partnership has led to an aquatic invasive species success story in Lake Champlain. Mechanical harvesting efforts reduced dense water chestnut populations over approximately 40 miles (representing both Vermont and New York shores) so that this stretch of the lake is now controlled by hand pulling and ongoing surveillance. 2007 mechanical harvesting efforts set additional milestones: efforts advanced four miles south of previous efforts for the first time in 27 years; 99% of the water chestnut plants collected thru the harvesting process were composted, up from only 19% in 2004; and rapid response actions occurred at all three newly confirmed infestation sites.

Biocontrol of *Lythrum salicaria* began in Vermont in 1995 with the release of three European insect species (two leaf-eating beetles, and one stem boring weevil) by the U.S. Fish and Wildlife Service. In July 1996, the State began releasing two species of leaf-eating beetles (*Galerucella* spp.). Since 1996, over 553,000 beetles have been released into more than 854 acres of purple loosestrife throughout 79 different towns in the state with loosestrife population reductions documented in many areas. This program, coordinated through the Agency's Wetlands Program, is ongoing, with continued releases and monitoring expected annually.

Ongoing State monitoring efforts and local control programs are underway for the other invasive aquatic or wetland species confirmed in the state: *Butamus umbellatus*, *Fallopia japonica*, *Hydrocharis morsus-ranae*, *Iris pseudacorus*, *Lythrum salicaria*, *Najas minor*, *Nymphoides peltata*, *Phragmites australis* and *Potamogeton crispus*.

The Program recently launched a newly rejuvenated version of its aquatic invasive species volunteer monitoring program. The new program, called *Vermont Invasive Patrollers* or VIPs, provides reference materials and comprehensive training workshops, and supports volunteer efforts to monitor local waterbodies for new aquatic invasive species incursions, species already in the state as well as those at risk of entering. Our Program relies heavily on volunteers like VIPs to fill the many gaps that exist in a Program with limited staff.

The first confirmation of the diatom algae species, *Didymosphenia geminata* (a.k.a. rock snot or didymo) in the Northeast United States was found this past summer in the northern reaches of the Connecticut River. Staff from the Vermont Agency of Natural Resources initiated a rapid response campaign in cooperation with staff from New Hampshire Department of Environmental Services, the fly fishing community, several watershed organizations and U.S. Fish and Wildlife Service. Subsequent populations were also confirmed in two additional rivers, the White River and the Batten Kill. Significant efforts on the regional level are underway to coordinate monitoring, surveillance and spread prevention initiatives, and to develop a regional public education campaign.

Native plant species – *Elodea canadensis*, species of duckweeds, *Nyphaea*, *Nuphar* and *Typha*, and others – often cause problems in lakes and the many ornamental and farm ponds that dot the state. Requests for identification and technical advice, permits and general information related to nuisance native plant species management represents a large component of assistance the Program provides.

Please visit the Vermont Aquatic Nuisance Species Program website to learn more about our grant opportunities, our process for obtaining an aquatic nuisance species permit, our prohibited aquatic and wetland plant species, VIPs, the latest update on current species like didymo or Vermont's aquatic invasive species efforts in general, www.vtwaterquality.org or email ann.bove@state.vt.us

Biological control of Hygrophila polysperma:
Searching for natural enemies in India -First Trip Report

A. Mukherjee[1] , J. P. Cuda[1], W. A. Overholt[2] & C. Ellison[3]

Introduction

Hygrophila, *Hygrophila polysperma* (Roxb.) T. Anders (Acanthaceae) is a federal-listed noxious weed, and an invasive aquatic plant in Florida that is spreading to other warm water areas of the United States and Mexico. This plant is a threat to all Florida waterways because it is capable of tolerating a wide range of water temperatures and its seeds or viable fragments can be unintentionally transported to new locations. Recent experiences in south Florida indicate that practical solutions for long term control of this plant are not currently available. Alternative methods are needed to address the Hygrophila problem in Florida in order to prevent the rapid regrowth and spread of this aquatic weed.

There is general agreement that Hygrophila is a good candidate for classical biological control. The risk for non-target damage by approved biological control agents would be low because only one native species in the genus Hygrophila occurs in the US. Classical biological control is an appealing option because the aquatic habitats infested with Hygrophila are relatively stable ecosystems conducive to biological control agent establishment, and the invasive characteristics exhibited by Hygrophila are consistent with the 'enemy escape hypothesis'. Because Hygrophila is an Old World species that is native to the southeastern Asiatic mainland (e.g. India), surveys of its natural enemies are needed because there is no information available on potential biological control agents for this aquatic plant. We recently traveled to India in order to establish cooperative agreements with collaborating institutes, and obtain locality information for Hygrophila by visiting different herbaria.

Figure 1. Dr. Jim Cuda (left) and Dr. Carol Ellison (right) in CABI, New Delhi office.

Figure 2. Meeting in PDBC, Bangalore, India, Dr. Rabindra (left) and his team.

Accomplishments

We arrived in New Delhi (previously Delhi) on 18 September 2007. The following day we met Dr. Carol Ellison (Figure 1.) to discuss specific project objectives. Dr. Ellison, a senior scientist and invasive species specialist with CABI, was hired as project consultant and liaison with the Project Directorate of Biological Control (PDBC). PDBC is an institute of the Indian Centre for Agricultural Research (ICAR) that is the central body of biological control research in India. During the course of this project CABI will be our main contact in India. Dr. Ellison is a Plant Pathologist who will provide expertise in isolating and identifying pathogens affecting Hygrophila.

On September 20th, a visit was made to Bangalore where Dr. Ellison met with Dr. Rabindra, the Director of PDBC (Figure 2.). As the primary organization for biological control research in India, PDBC has well equipped laboratories and field stations for conducting surveys and rearing of natural enemies. A presentation was made containing background information and specific objectives of the project. Dr. Rabindra and his team were impressed by the objectives of the project and assured us of their cooperation.

Collection of Herbarium Information

After reaching Kolkata (previously Calcutta) on September 29th, our primary objective was to collect herbarium records of Hygrophila before initiating local surveys. On October 1st we visited the 'Central National Herbarium' located in the 'The Botanic Garden', Howrah, Kolkata on 1 October. Established in 1795 by Dr. Willium Roxburgh, 'The Central National Herbarium' popularly known as CNH, is one of the oldest and largest herbaria in the world. Currently, the CNH

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houses about 2.5 million herbarium specimens representing nearly 350 plant families; the specimens are arranged according to Bentham and Hooker's system of classification. The herbarium Director was kind enough to allow us to access the data base. In total, 64 specimens of Hygrophila were examined and the locality information/ecological notes recorded. The herbarium's records indicated that Hygrophila was collected from 12 Indian states, the majority of samples (26 of 64, or 41%) from the state of West Bengal in northeast India. The earliest record dates back to 1910 and at least one sample were collected at an altitude of 1200m. Locality information of Hygrophila is presented in Figure 3 (expanded to include Kew Herbarium Records). It is evident from the available data that Hygrophila is widely distributed. Contact also was made with the Director of the Herbarium at Kew, London, to arrange a visit to examine their Hygrophila collection. This will help to delimit the distribution of Hygrophila in its center of origin.

At Kew, there are specimens of Hygrophila dating back to 1841. The data was incorporated into Figure 3, expanding the recorded range of the weed in India. This data also helped us to delimit the distribution of *H. polysperma* throughout its native range: there are plant specimens dating back to the 1800's and early 1900's from Pakistan, Burma, Vietnam, Taiwan, Sri Lanka and Malaysia.

Survey in Local Aquarium Market

Conducting a field level survey based entirely on the herbarium records was difficult due to time constraints. Therefore, we visited the local aquarium market to find out if Hygrophila is being sold commercially. We contacted local aquarium shops and found out that it might be sold in the Sunday 'Hat'. Hat, in local dialect, is a market that takes place once a week where people from distant places usually come and sell their products, similar to 'Flea Market' in the US. We located a person selling various aquatic plants and were fortunate to find Hygrophila among all the different plants being sold (Figure 4). We purchased some plants from the vendor and also inquired about their location. He agreed to accompany us to those places where he collected the Hygrophila.

Identification of *Hygrophila polysperma*

Before going into the field to perform the surveys, proper identification of the plant was important. We contacted Professor G. G. Maiti of the University of Kalyani in West Bengal. Dr. Maiti is a plant taxonomist specializing in biosystematics of angiosperms. He was very helpful to us and confirmed the identification of the plants we collected from the market. Those plants were indeed *Hygrophila polysperma*.

Local Survey for Hygrophila

The main purpose of this initial survey was to locate existing populations of Hygrophila, search for any incidence of insect feeding damage, and geo-position the plant's location (Figure 5). Collection of the plants for further genetic analysis was another important objective. In this first survey in Kalyani, West Bengal, Professor Maiti accompanied us on the trip. We were able to locate the plant at Muratpur, Kalyani, and West Bengal (Figure 6). Since the time of the year when we carried out this survey was just after monsoon season, the main problem that we faced was gaining access to the flooded water bodies. However, it was apparent that this plant grows abundantly in marshy areas of West Bengal. We performed additional surveys (a total of 6 surveys were conducted) around West Bengal to geo-reference existing populations of Hygrophila.

Searching for natural enemies also was part of our initial survey. During the course of our survey we observed some insect feeding

Figure 3. Map showing the distribution of Hygrophila (shaded area) in India. Based on herbarium records collected from Central National Herbarium, India & Kew, England.

Figure 4. Hygrophila for sale in local market.

Figure 5. Georeferencing local Hygrophila populations.

Figure 6. Map showing geo-referenced Hygrophila populations. Location 1 (Lat 22.985375, Long 88.435753) hygrophila growing along canal bank in West Bengal. Location 2 (Lat 22.436111, Long 88.39461) large patch of Hygrophila.

Figure 7. Insect damage on Hygrophila.

Figure 8. Hygrophila auriculata leaves showing insect damage.

damage on the leaves (Figure 7), but we were unable to collect or identify the natural enemies at this time.

Survey for Natural Enemies on *Hygrophila auriculata*: A Closely Related Species of *Hygrophila polysperma*

While in India surveying for natural enemies of *H. polysperma* we located another species, *Hygrophila auriculata* (Schum), which is similar of the target weed *H. polysperma*. *Hygrophila auriculata* occurs in the same habitat preferred by *H. polysperma* and thus provided us with an opportunity to survey for genus-specific natural enemies. The purpose of this survey was to collect samples of *H. auriculata* and confirm the identity of this species. While collecting the samples, we also found insect damage and disease symptoms affecting the plant (Figure 8). Although we were unable to specifically identify the natural enemies impacting *H. auriculata*, our findings clearly showed the potential for obtaining insects and pathogens from this species of Hygrophila. There also is published report of larvae of an agromyzid fly boring into the stems of H. auriculata. Additional surveys in 2008 will focus on this natural enemy.

Establishment of a field station:

Establishment of a field station was another important objective of this first trip to India. This field station will be used to establish a culture of pathogens and search for insects before transporting them to the PDBC laboratory in Bangalore for further identification and rearing. It is quite evident from the available data that the eastern part of India is very favorable for the growth of Hygrophila. Therefore, having a field station in this particular area will be essential for the success of the project. We were able to establish a cooperative agreement with the Krishi Vigyan Kendra (KVK) of the Agriculture Research Institute in Nimpith, West Bengal. KVK is an affiliated institute with Indian Council of Agriculture Research (ICAR) that is dedicated to transfer of technology from 'lab-to-land'. The KVK agreed to provide laboratory space for our use.

Acknowledgements:

This research project is supported by grants from Osceola County, Florida and the Florida Department of Environmental Protection.

For further information on Hygrophila use the following references:

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AQUAVINE

Awards and recognitions were presented at the 2007 Annual FAPMS Conference in St. Petersburg, FL. Here is a brief summary of the accolades presented:

Applicator of the Year
Calvin W. Long -United States Army Corps of Engineers (USACE)

Calvin fulfilled the requirements necessary to be an excellent applicator. In addition, he helped teach plant identification sessions to co-workers and agency personnel. As an airboat operator/trainer, he volunteered to transport airboats and train District staff from New Jersey and Philadelphia on treating Phragmites while safely operating an airboat.

President's Award

Bill Moore: in recognition of the many contributions made to the Florida Aquatic Plant Management Society.

Mike Page: in recognition of the many contributions made to the Florida Aquatic Plant Management Society.

Board of Director 2005-2007

Dr William (Bill) Haller, University of Florida/IFAS
Johnnie Drew, St. Johns River Water Management District (SJRWMD)
Michael Netherland, United States Army Corps of Engineers (USACE)

Presenting Applicator Paper

Randal Snyder, St. Johns River Water Management District (SJRWMD)
James Schultz, Lake Worth Drainage District
Steve Montgomery, All State Resource Management
Henry James, City of Orlando
Kenneth G. Sonne, Jr., Lee County Hyacinth Control District

Best Applicator Paper

1st **Steve Montgomery**, All State Resource Management
2nd **Kenneth G. Sonne, Jr.**, Lee County Hyacinth Control District
3rd **Randal Snyder**, St. Johns River Water Management District (SJRWMD)

Photo Contest Award Ribbons

Aquatic Operations
1st Buddy's Blunder by **Adam Johnson**
2nd Hygrophila by **Joyce Hertel**
3rd Spraying Cattails by **Boyd Thompson**

Aquatic Scene
1st Lake Wilmington (Blue Cypress) by **Joyce Hertel**
2nd Parrot feather with drew drop by **Boyd Thompson**
3rd Otter by **Charles Burn**

Calendar

April 21-24, 2008
23rd Annual Florida Exotic Pest Plant Council (FLEPPC) Symposium, Crowne Plaza Hotel Jacksonville-Riverfront. Jacksonville, Florida, www.fleppc.org

May 5-8, 2008
2008 Aquatic Weed Control Short Course, Coral Springs Marriott Hotel, Coral Springs, FL www.conference.ifas.ufl.edu/aw/.

June 2-5, 2008
2008 NALMS Southeast Regional Conference, Sandestin Golf and Beach Resort in Sandestin, Florida. , www.flms.net

July 13-16, 2008
48th Annual Aquatic Plant Management Society (APMS) meeting. Charleston, SC., www.apms.org

Aquatic Plant Management Society

Announces Annual Student Paper Contests for Upcoming July 2008 Meeting in Historic Charleston, South Carolina

The Aquatic Plant Management Society (APMS) is soliciting student papers for their upcoming 48th Annual Meeting to be held July 13 - 16, 2008, at the historic Mills House Hotel in Charleston, South Carolina. 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 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. This meeting presents an opportunity for students to develop their presentation skills, learn about the field of aquatic plant management, and network with key Government, University, Industry representatives and peers with similar educational and professional interests.

Please log on to **www.apms.org** to learn more about the Aquatic Plant Management Society and this year's meeting. Students may register for the contest by submitting an abstract as per web site instructions.

Additionally, immediately following this years meeting APMS is organizing a student tour, in cooperation with the South Carolina chapter of APMS, to observe regional weed management issues. Observations of phragmites, alligatorweed, and hydrilla management projects are possible, as well as a potential stop at a research lab. The tour is tentatively scheduled from Wednesday afternoon (July 16th) to Thursday afternoon (July 17th), and is dependent on total participation. Please contact Tyler Koschnick (*information below*) if you are interested in participating in the tour.

For more information, please contact:
Dr. Tyler J. Koschnick, Aquatic Research Manager
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E-mail: tylerk@sepro.com


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