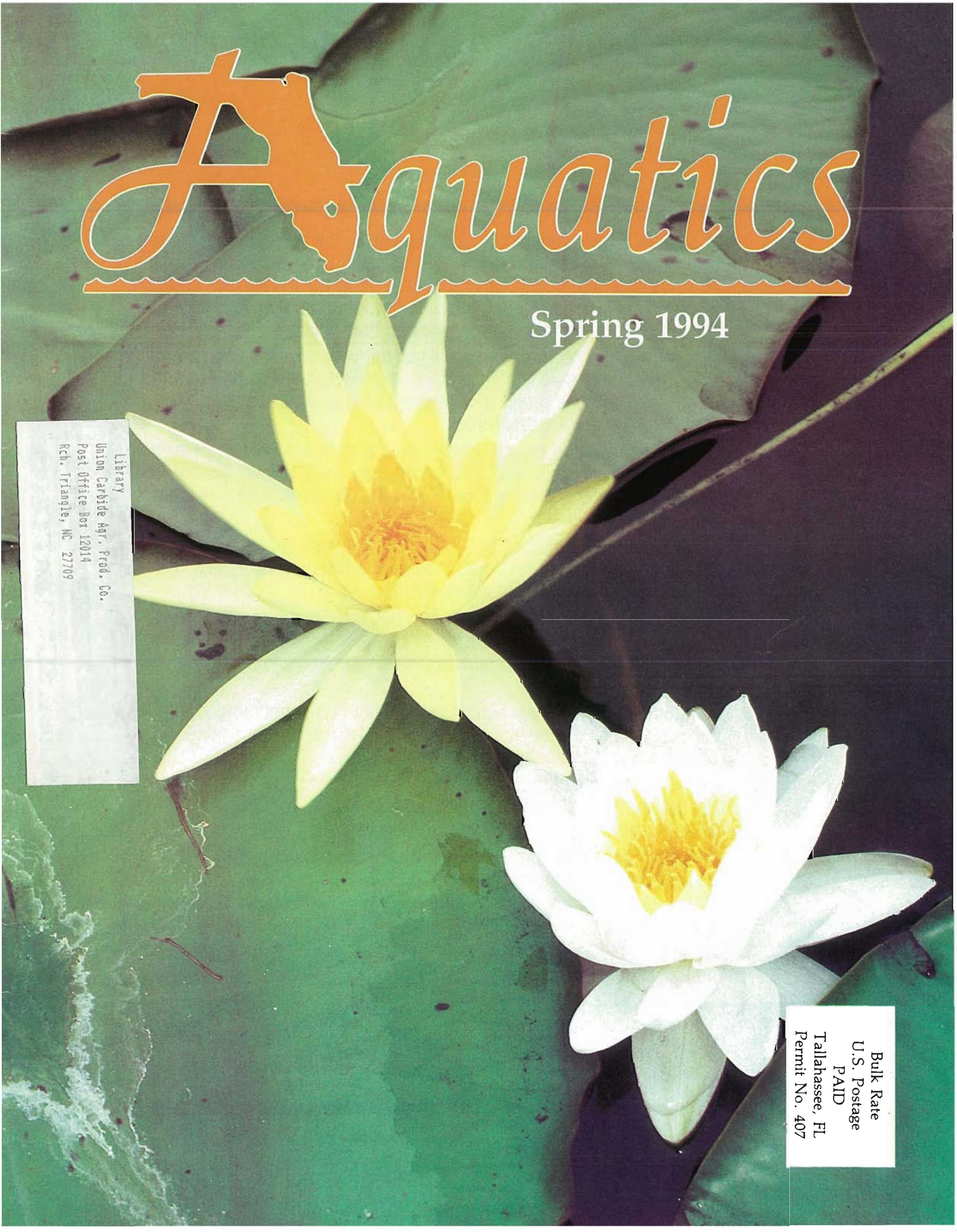
Aquatics

Spring 1994



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Letter to the Editor

The mention of "hydrilla" seldom evokes an impartial opinion by people who take advantage of Florida's varied freshwater recreational opportunities. To some, "hydrilla" means burned up outboard motors, lack of navigation, and just a plain and simple "weedy mess". However, to others, such as largemouth bass fishermen, hydrilla means winning a tournament, catching dinner or just plain and simple "good fishing".

The adaptation of hydrilla to grow in low light conditions not only allows hydrilla to outcompete native submersed vegetation, but also allows hydrilla to grow in lakes that, either because of nutrient enrichment or natural forces, are too murky for abundant stands of native submersed aquatic plants. Similar to native aquatic submersed plants, hydrilla benefits sport fishes, especially largemouth bass, in several ways. It provides habitat for aquatic invertebrates and other small organisms which are important food sources for young largemouth bass, as well as for forage fish and other sport fishes. Hydrilla also can protect young largemouth bass from predation by larger fish and protect spawning beds from wind and wave action. It can contribute to better fishing by providing an important edge effect, and clearing up pea-green water by absorbing excessive nutrients.

Uncontrolled hydrilla can completely cover a body of water and may be detrimental to sportfish populations. However, biologists have found that fluctuating hydrilla levels can create an incredible largemouth bass fishery. Increasing hydrilla provides habitat suitable for strong year classes of largemouth bass, forage fish and other sport fishes. Decreasing hydrilla coverage can expose forage fish produced in the hydrilla to predation, subsequently causing increases in the robustness of bass, while also increasing their susceptibility to angling. With this type of habitat manipulation, angler catch of largemouth bass on Lochloosa Lake increased from 21,000 bass in 1988 to 43,000 bass in 1991, even with a 40 percent decrease in fishing effort!

Should hydrilla be advocated as a fish management tool? Hydrilla driven fisheries should not be advocated in lakes with a healthy abundance of native submersed vegetation. However, we have many degraded lakes in which this tool could be of major benefit, at least until these systems are made suitable for native submersed vegetation. Because of the fish management possibilities and problems with uncontrolled growth of hydrilla, scientists and managers should work closely together to better refine methods to manage this plant.

Jim Estes

Florida Game & Fresh
Water Fish Commission
Gainesville, FL

This photo of sulphur water-lily (upper) and fragrant white water-lily was reproduced in black and white in David Sutton's article on "Water-lilies of Florida" in the Winter 1993 issue of *Aquatics*. The photo should have appeared in color to demonstrate the difference in color of the petals that is produced when the yellow and fragrant (white petals) water-lilies hybridize naturally.

Aquatics

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Summer Treatment of Hygrophila with Endothall in South Florida

by
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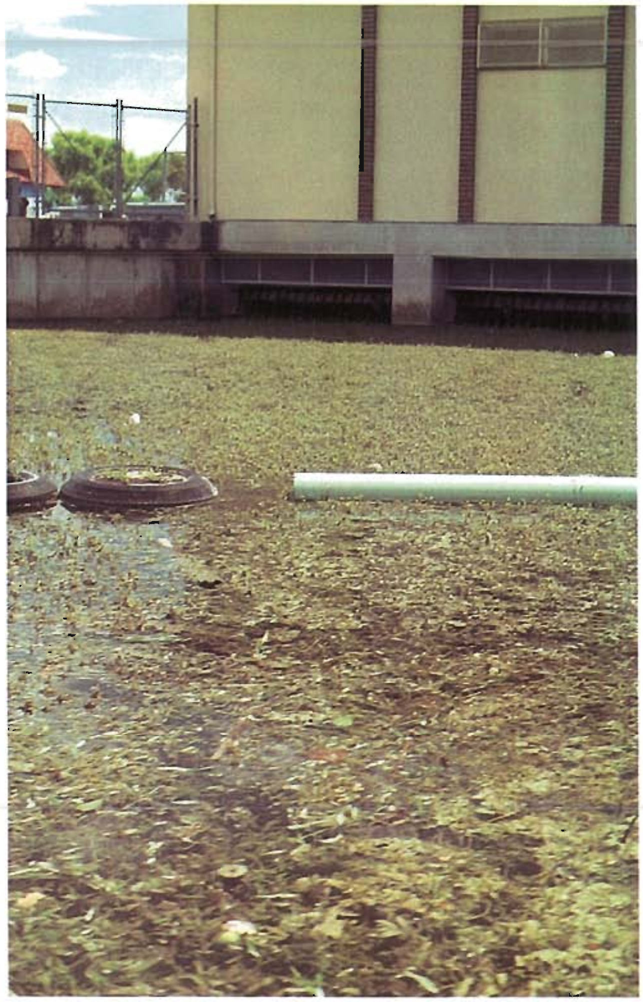

Figure 1. East Indian Hygrophila blocking water flow to a water control structure.

Introduction

East Indian Hygrophila (*Hygrophila polysperma* (Roxb.) T. Anderson), an aquatic plant native to India and Asia, is creating problems in canals and other bodies of water in South Florida. This exotic plant forms dense monocultures but does not produce the extensive surface branching of Hydrilla (*Hydrilla verticillata* (L.f.) Royle).

A characteristic growth habit of East Indian Hygrophila is its tendency to produce many adventitious roots at the nodes along the stem. The stems are brittle and fragment easily. Fragments float for long periods of time and create problems around water control structures (Figure 1). These fragments may also be a source of new infestations.

Although East Indian Hygrophila naturalized in Florida a number of years ago, only during the past few years has its population increased to the point where it is now a major nuisance. Control of Hydrilla may be one reason for the increase in East Indian Hygrophila populations.

East Indian Hygrophila is relatively resistant to herbicides currently approved for control of Hydrilla as well as other herbicides approved for aquatic situations. However, endothall products have shown some potential for control of East Indian Hygrophila. Therefore, a herbicide treatment was conducted in the Old Plantation Water Control District (OPWCD) in South Florida to provide information on endothall products that might be useful for control of aquatic weed problems caused by East Indian Hygrophila plants.

Herbicide treatments

Canals in the northeastern section of the OPWCD with fairly uniform growth of East Indian Hygrophila plants were selected for the herbicide treatment (Figure 2). The herbicide treatment area consisted of two control plots and duplicate herbicide plots (West and East). The West plot, Sites 7 to 10, consisted of 0.7 surface hectares (1.8 acres) at a depth of 1.17 meters (3.8 feet); and the East plot, Sites 4 to 6, consisted of 0.7 surface hectares (1.8 acres) at an average depth of 1.2 meters (4.0 feet). The Control plots consisted of Sites 1 to 3 and 11 to 13. Sites 1 to 3 were used in the plant survey and all sites in the control areas were used in the water quality measurements.

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Endothall herbicide in three different formulations was applied on August 24, 1993 to achieve 3.0 ppm using Aquathol G, 1.5 ppm using Aquathol K, and 0.2 ppm using Hydrothol 191 G in each of the duplicate herbicide plots. The control area did not receive any herbicide although some drift of herbicide may have occurred from the East plot into Sites 2 and 3 of one of the control areas.

Before application of the herbicides, a plant survey was conducted August 19, 1993 in the control and herbicide areas by stretching a transect line across the canal at each of the 10 sites. Aquatic plants were recorded at 1.0 meter (3.3 feet) intervals along the line. A frequency of occurrence of plants as a percent of those present at each 1.0 meter interval was calculated. The plant survey was repeated 4, 8, and 12 weeks following the herbicide treatment.

Water quality analyses were performed using portable field instruments. Dissolved oxygen in parts per million (ppm) and temperature in degrees Celsius (C) were measured using a YSI Model 57 dissolved oxygen meter, and conductivity values as micromhos per centimeter (umhos/cm) were determined using a YSI Model 33 conductivity meter. All water quality measurements were taken in situ 1 day before and 1, 2, 7, 14, 28, 56, and 96 days after the herbicide treatment. Measurements were obtained at a depth of 0.5 meters (1.6 feet) starting at 1:00 PM at Site 1 and continuing in numerical order to Site 13 until about 3:00 PM. Water quality measurements were collected in Sites 11 to 13 only following treatment of the herbicide. Measurements from Sites 11 to 13 were then combined with data from Sites 1 to 3 for use in comparison of measurements taken in the herbicide treated areas.

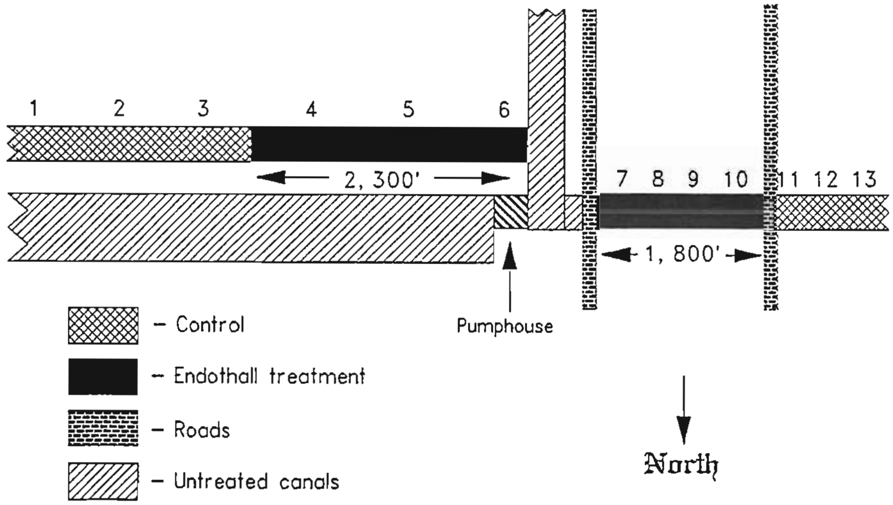

Figure 2. Schematic of canals in the Old Plantation Water Control District used for treatment of East Indian Hygrophila with endothall herbicides.

Results and Discussion

Water flow in the OPWCD is minimal except during periods of rainfall, but there is a gradual movement of water throughout the system. In the canal used for the endothall treatment, there is a natural flow in the direction from Site 10 to Site 1. The extent to which this flow of water influenced activity of the applied herbicide is unknown. However, the decline in East Indian Hygrophila in Sites 2 and 3 of one of the control plots after application of endothall suggests that some herbicide may have drifted out of the East plot (Sites 4 to 6).

Frequency of occurrence of East Indian Hygrophila in the test plots prior to application of endothall

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herbicides, ranged from slightly over 20% to almost 50% based on measurements at the 10 sites (Figure 3). Within 4 weeks after application, plant growth as determined by frequency of occurrence for all treated sites was less that 10%; however, after 8 weeks plant growth was almost back to pretreatment levels except for Sites 4 and 5. East Indian Hygrophila remained low downstream in Sites 4 and 5 after 12 weeks. Although measurements for biomass of East Indian Hygrophila were not determined in this study, field observations indicated a significant reduction in overall plant biomass 12 weeks after application of herbicide.

Dissolved oxygen values in the control sites were lower than those collected prior to treatment (Figure 4). Cloudy weather that followed the herbicide treatment may have influenced the amount of dissolved oxygen measured. Dissolved oxygen values in the endothall treated area were lower than the control within 1 day after application of the herbicide. The values remained low for the 2-day measurement followed by a gradual rise until no differences were noted 96 days following application of herbicide.

Water temperature at the time of treatment was 30 C (86 F) and reached a low of 25 C (77 F) 96 days after treatment, but no differences were observed between the control and endothall treated areas. Similarly, no differences were noted for conductivity readings between the control and herbicide treated areas. Conductivity was 500 umhos/cm prior to treatment, but dropped to 454 umhos/cm 7 days after treatment. The drop in conductivity 7 days after treatment may have been related to rainfall when the pumps had to be turned on for a short time prior to the 7-day sampling time. However, by 96 days after treatment, conductivity had returned to levels only slightly higher than the pre-treatment measurements.

Endothall is readily absorbed by leaves and roots; however, it does not translocate from the leaves and exhibits limited translocation from roots to the leaves of plants. The Dipotassium salt of endothall has low toxicity to fish. Endothall is rapidly degraded in both soil and water by microbiological breakdown. Due to this rapid degradation by microbes, treatments during cooler weather may be more effective than during the warmer summer months when temperature would increase microbiological activity. Additional endothall treatments are planned for the winter of 1994 to determine if better control of East Indian Hygrophila can be achieved during the cooler winter months than was obtained in this study.

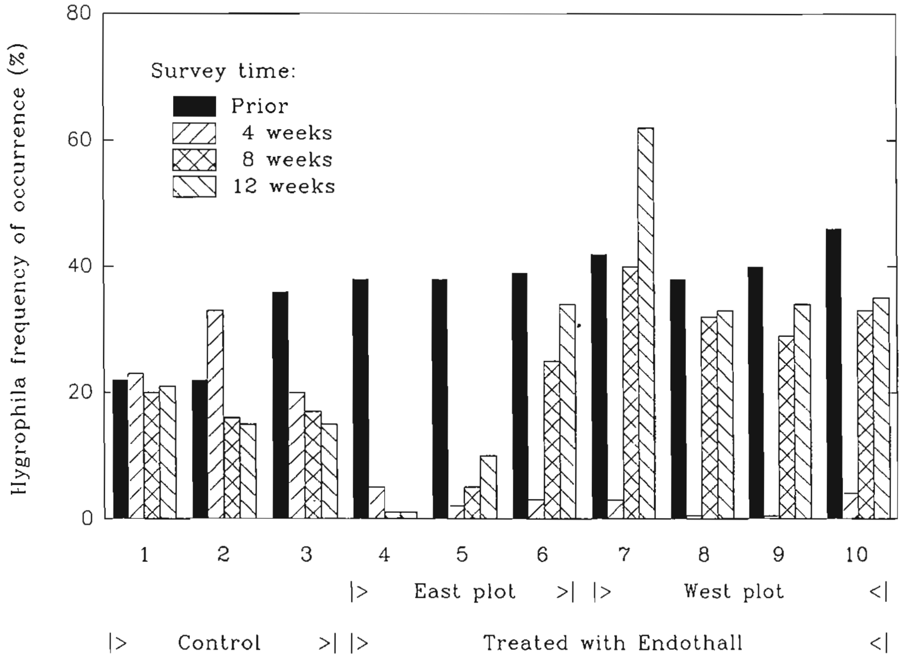

Figure 3. Frequency of occurrence of Hygrophila in the control and endothall treated plots.

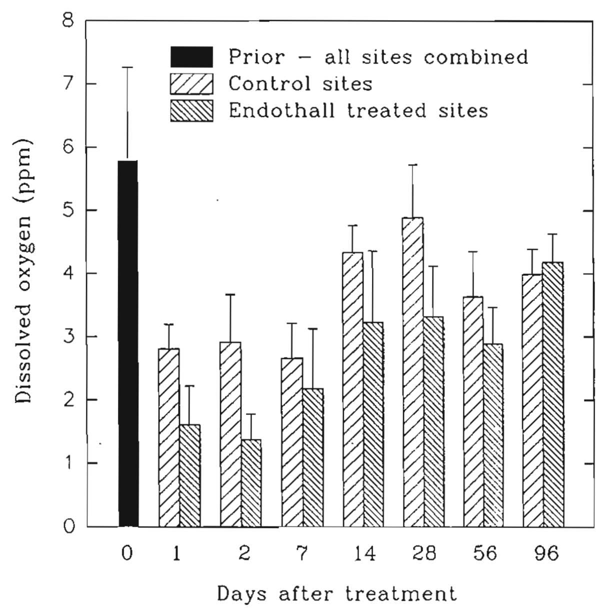

Figure 4. Dissolved oxygen of water in canals treated with endothall products for control of East Indian Hygrophila.

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Fighting Eurasian Watermilfoil in Wisconsin

by
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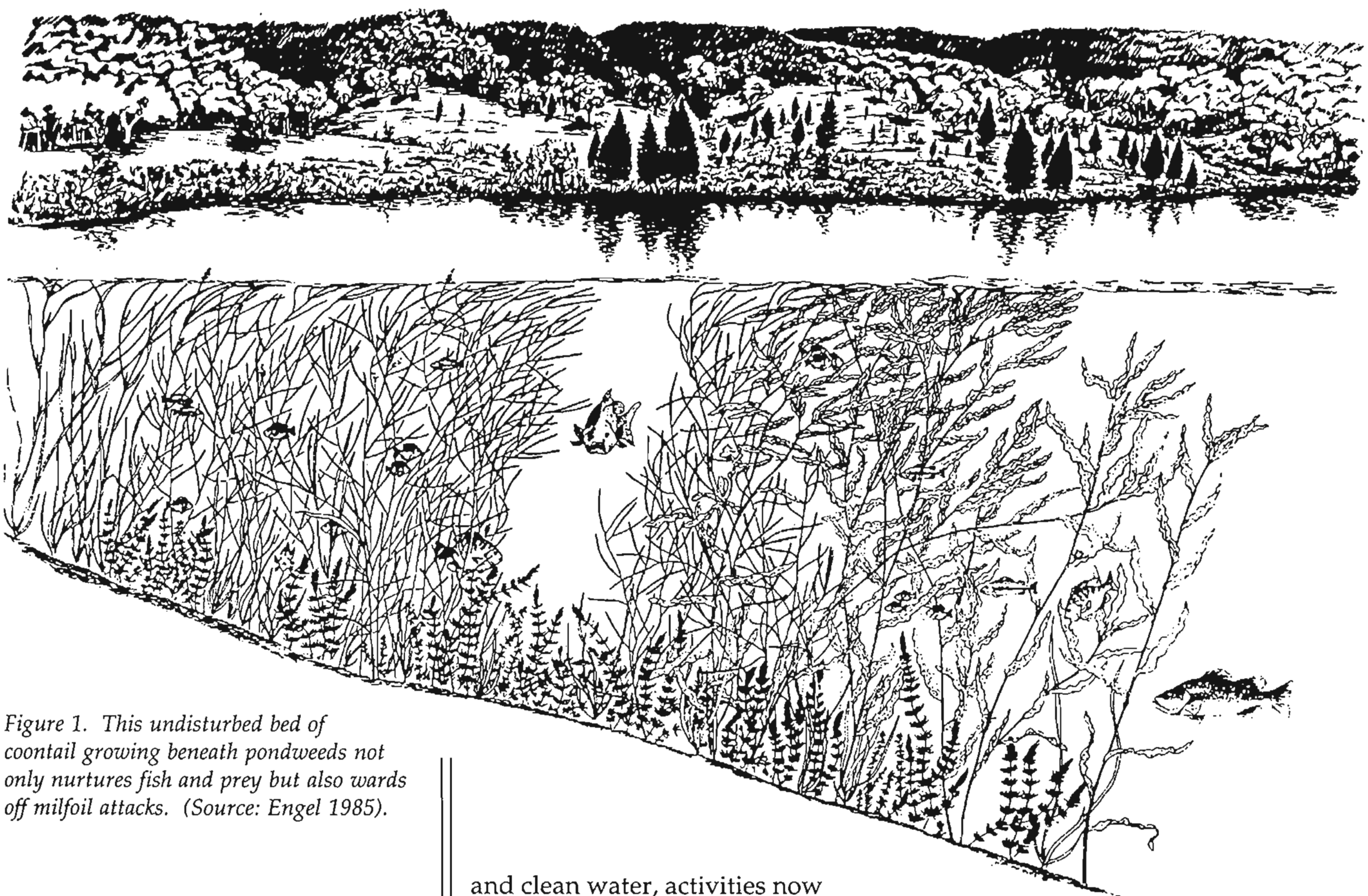

Figure 1. This undisturbed bed of coontail growing beneath pondweeds not only nurtures fish and prey but also wards off milfoil attacks. (Source: Engel 1985).

Wisconsin has declared war on Eurasian watermilfoil (*Myriophyllum spicatum*). After spreading across North America for two decades (Couch and Nelson 1985), this underwater superweed hit southern Wisconsin in the 1960s. Within 20 years it claimed 54 lakes in 26 southern counties. Since 1987 it has spread north into 13 more counties and now grows in at least 75 lakes statewide.

This recent spread across northern Wisconsin has folks here worried and lake managers preparing battle plans. The state's tourist industry depends on good fishing and clean water, activities now threatened by watermilfoil. And yet with thousands of Wisconsin lakes, the fight against superweed has only begun.

Keys to Success

Our's is a war against shoots and stolons. Watermilfoil shoots break off and drift downstream to new waters. Others attach to objects—boats, trailers, motor propellers—and so travel roads to new lakes. When such fragments take root, a pioneer colony forms and becomes the focus of spread within a lake. One key to fighting superweed, therefore, must be *to keep these fragments away from new waters or to remove them before they form roots.*

Pioneer colonies spread by stolons—runners that creep along the lake bed claiming territory inch by inch. Along these stolons new shoots sprout that in turn produce fragments. Disrupting native plant beds—by speed boating, plant harvesting, or using herbicides—can open even more sites for creeping stolons. Some believe a dense mat of stolons can keep native plants from reclaiming these sites. And so a second key to fighting superweed must be *to remove pioneer colonies before they spread by stolons or shoots.*

Fighting back means reclaiming lakes as well, lakes long dominated by superweed. By wintering as green shoots, by sprouting soon after ice-out (when ice melts in Spring for you southern folks), and by leafing out on the water surface (Engel 1990a), superweed can beat the competition and form dense beds that shade native plants and stop speeding boats. Water turbidity even seems to lengthen shoots and encourage canopy formation. Thus a third key to managing these lakes must be *to control canopy growth and plan better lake use.*

So we must fight back on three fronts: prevent initial colonies in lakes still without watermilfoil, keep these colonies from spreading in lakes new to watermilfoil, and reduce growth in lakes long choked with the weed.

Three Ounces of Prevention

Allowing superweed to claim yet another victim lake can be a costly mistake. Last year harvesting mainly watermilfoil cost over $250,000 on the Madison lakes (Kenneth J. Koscik, Dane County Public Works, pers. comm., 1992) and over $100,000 on Pewaukee Lake (Charles R. Shong, Lake Pewaukee Sanitary District, pers. comm., 1992).

But can superweed be kept out? Preventing a milfoil attack seems hopeless against a flood of fragments hitching rides on boats and trailers. And yet most folks become aware of watermilfoil only after it has already colonized their lake. They have little chance to prevent a milfoil attack . . . unless they stay alert.

Preventing a milfoil attack will take a triple defense: a public vigil against weed fragments at boat landings, a commitment to protect native plant beds from speed boaters and indiscriminate plant control, and a watershed management program to keep nutrients from reaching lakes and stimulating milfoil colonies.

Sounding the Alarm

Preventing a milfoil attack in Wisconsin will take an informed and determined citizenry, organized for an all out milfoil alert. Such an alert must consist of a *media campaign* to tell others about superweed, a *weed watch* to patrol shorelines, someone to properly *identify pioneer colonies*, and a *plan of attack.*

Media campaigns against watermilfoil have worked in British Columbia, Minnesota, New York, and Washington. They include pamphlets, signs, press releases, articles, radio and television spots, and public talks (Engel 1989). Pamphlets can be handed out at bait shops, boat landings, diving shops, lake fairs, state parks, and water shows. Signs posted at boat landings, highway rest areas, and marinas can tell people what milfoil looks like and how it can be removed from boats, trailers, and motor propellers. Press releases and newsletter articles can help lake associations, angling clubs, and other service groups spread the word.

Some states even outlaw the transport of weed fragments and require people to clean plants off boats and trailers before using public waters.

Such campaigns must be aimed at lake managers as well as lake users.

Plant harvesting crews must inspect their boats when leaving or entering lakes. Herbicide applicators must use more selective herbicides and use them judiciously. Nurseries that sell aquatic plants must raise native plants and not rob them from lake shores. Even fish management crews must inspect their boats and nets for shoot fragments.

A weed watch should be organized to patrol shorelines by foot and boat every few weeks during the growing season (De Steno and Larson 1990; De Steno 1992). Assigning at least two people to watch each shoreline can avoid absentee and morale problems. A watch supervisor able to identify Eurasian watermilfoil will be needed to advertise for volunteers, schedule watch teams, and respond to milfoil sightings. Look for milfoil fragments after summer weekends, especially on downwind shores and around boat piers.

Citizen volunteers should target marinas and public landings—ports of entry for milfoil fragments. Here boat cleaning stations can be staffed to help boaters remove weed fragments before entering or leaving lakes. Here, too, citizens can broaden their support through public education about watermilfoil.

But speakers and spotters are not enough. A lake management plan must be developed to protect and even restore native plant beds that compete with superweed. Wisconsin law (s. 29.54) already prohibits people from picking native aquatic plants important as waterfowl food, but the law must be broadened to protect other native plants. A lake plan should set aside habitat zones and keep them away from speed boating, herbicide spraying, and mechanical harvesting. Such zones might need to be planted with native seeds, tubers, and shoots to improve habitat diversity (Engel 1988).

Aquatic plant surveys should be conducted in summer, to assess future plant community changes. These surveys should list all macroscopic plant species growing underwater and describe each one's abundance and distribution out from shore. Dried specimens of each species—pressed between newspapers and labeled at least with lake name, location on lake, and collection date—should be sent to a recognized herbarium for future reference. Such surveys might even reveal superweed.

A watershed management plan must be developed as well, to retard soil erosion and runoff that add unwanted nutrients to a lake. Such nutrients can collect in lake sediment and someday fuel explosive growths of superweed.

Slowing the Spread

Should Eurasian watermilfoil penetrate a milfoil defense, pioneer colonies are likely to spread. Before they get out of hand, though, its time to get tough with SWAT—Shoreline Weed Attack Teams (Engel 1992).

Folks on some Wisconsin lakes already use SWAT to remove trash and debris from beaches, to cleanup after storms, and to fix piers. Now SWAT can swoop down on identified pioneer colonies, removing shoots with roots. Hand pulling means wading, snorkeling, or SCUBA diving after milfoil colonies. Such teams should form early in summer and stay on call so little time is lost when weed watchers find new colonies. A Minnesota lake management company even advertises:

> "A team ready to travel anywhere on a moment's notice for the purpose of eradicating pioneer infestations of Eurasian watermilfoil with SCUBA-assisted hand removal."

Use hand pulling for colonies under 0.75 acres (Steve McComas, pers. comm.) or less than 100 plants (Madsen et al. 1989). Weed watchers should mark each identified colony with buoys to warn boaters away. Take care to remove roots and keep shoots from breaking apart during removal. Sites away from boat traffic can then be covered, under state permit, with burlap to prevent further sprouting at the site.

Larger colonies can be covered with fiberglass screen, vacuumed with a suction dredge, or treated as a last resort with a herbicide. These techniques require a state permit as well.

Bottom screens, anchored firmly against the lake bed, kill grown shoots and prevent new sproutings, but must be removed each fall for cleaning off sediment that encourages rooting (Mayer 1978, Perkins et al. 1978, Engel 1984).

Pellets of 2,4-D can be inserted beneath these screens or through the water. This herbicide can drift onto native plant beds, but is more selective for watermilfoil than other broader-spectrum herbicides.

A diver-operated suction dredge can vacuum up weeds. It consists of a centrifugal jetting pump to lift dredge spoils into a wet well, where plants and debris are separated from lake water. But the technique can destroy native plants nearby and temporarily raise water turbidity.

These control sites can become customized management zones, sites dedicated not just to routing milfoil colonies but to building diverse and beneficial plant communities. Colony removal, for example, can be followed by planting native plants to stabilize shorelines against wave action, build nurseries for fish fry, and attract waterfowl. Imagine a milfoil shoot trying to land in a forest of native pondweeds and coontail (Fig. 1).

Reclaiming Milfoil Lakes

SWAT and Weed Watch come too late for lakes already choked with superweed. With milfoil growth at times exceeding an inch per day, heavy artillery will be needed. And that means mechanical cutters and harvesters. But these machines create shoot fragments that aid watermilfoil spread and open areas for invading plants (Engel 1990a, 1990b). That's why they should be used only after milfoil colonies have become widespread.

Mechanical cutters and harvesters can open areas for boating and swimming, form fish cruising lanes across dense stands, and even encourage spread of native plants by removing milfoil canopies that cast shade (Fig. 2). Cutters work best inshore, where they assist hand pulling and bottom screening. Harvesters work best offshore, where they have room to turn. Both machines can assist SCUBA divers to improve angler access through dense foliage. Offshore and inshore areas, therefore, need not be managed alike.

Learning to live with Eurasian watermilfoil is sometimes the best strategy. Continual disturbance by boating, harvesting, and herbiciding could maintain superweed. It has even declined on its own in some lakes after a decade of nuisance growth

Stay on Alert

Citizens are the cornerstones of any struggle against Eurasian watermilfoil. But preventing or controlling superweed is a lifetime commitment. That means staying alert to new ways of fighting Eurasian watermilfoil, such as *Lake Call*, for citizens to telephone new sightings, and *Lake Inform*, for experts to explain more about lakes and their proper management (Engel 1992).

Citizens must also stay alert to outmoded ways of fighting watermilfoil, ways that destroy all plant life. Wisconsin discourages whole lake treatments with herbicides because of potential impacts to nontarget plant communities, and outlaws grass carp, because they disrupt whole ecosystems by wiping out both exotic and native plants. Why destroy your lake ecosystem just to score against milfoil?

Wisconsin's Aquatic Plant Management program (Wisconsin

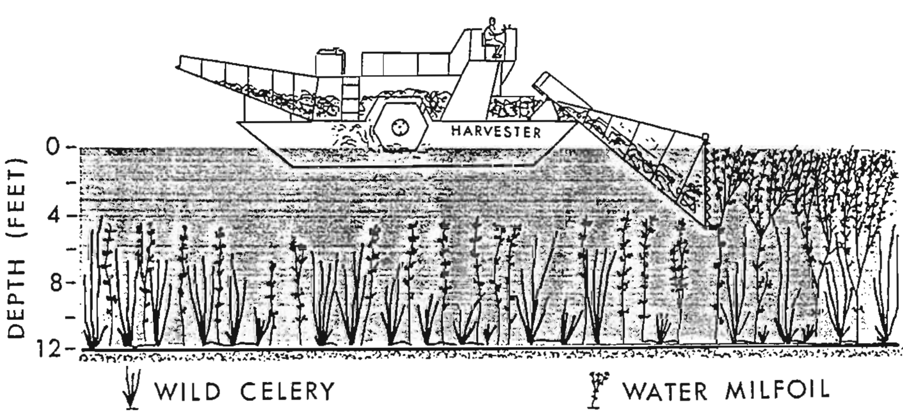

Figure 2. Mechanical plant harvesters can remove bushy canopies of Eurasian watermilfoil that shade underlying native plants, such as these grasslike wild celery. (Source: Engel 1987).

Administrative Code NR 107), which regulates aquatic herbicide use in the state, stresses a judicious approach to weed control. This program leaves room for native plant communities and recognizes their benefit to fish and wildlife.

Both citizens and lake managers can stay alert by working together on a lake management plan, one that not only prevents and controls Eurasian watermilfoil but also improves lake use for people and aquatic life. Such a plan can integrate diverse plant control options and guide their judicious use. Working together, citizens and managers can lick the milfoil menace.

Acknowledgements

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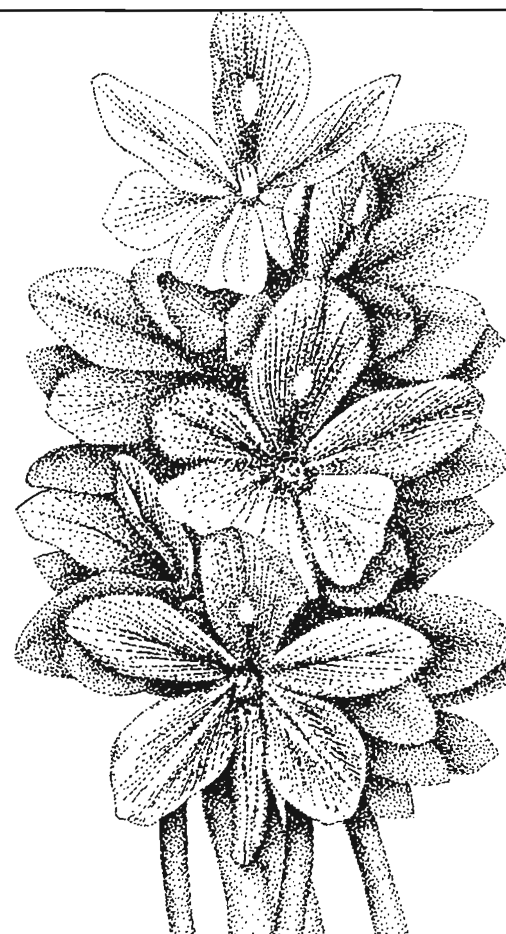

Air Monitoring of 2,4-D and Diquat Used in Aquatic Plant Control Programs

by
James D. Smith, M.S., CSP, and Harry Pullum, CSP, CIH
South Florida Water Management District
West Palm Beach, Florida

Introduction

The South Florida Water Management District presently has approximately 70 employees in the vegetation management program. These employees currently use approximately 12,853 gallons of 2,4-D and 6,500 gallons of diquat per year in their implementation of the aquatic plant control program.

In 1988, the District began an air monitoring study to determine exposure levels experienced by employees while using 2,4-D and diquat during conventional airboat spraying operations.

Methods of Testing

Employees were randomly selected from the Okeechobee, Clewiston and Kissimee areas to provide a reliable test study. Air monitoring studies were conducted on both the sprayer and the airboat operator. There were five (5) independent industrial hygiene air monitoring studies conducted, in which 2,4-D and diquat were used during aquatic plant control spraying.

The National Institute of Occupational Safety and Health (NIOSH) 5001 test method was used for the 2,4-D air monitoring procedures. The testing method required the certified industrial hygienist to use a flow rate of 1-3 liters per minute, with minimum volume of air at 15 liters, and a maximum volume of 200 liters, using a glass fiber filter as the capture medium.

The Occupational Safety and Health Administration (OSHA) Lab, Salt Lake City, test method IMIS 2681 was used for the diquat air monitoring procedures, as no NIOSH analytical test method exists. The testing method required the CIH to use a flow rate of less than 2 liters per minute, with minimum volume of air to be more than 90 liters, and a glass fiber filter as the capture medium. DuPont Alpha 1 powered sampling pumps were used and were calibrated, prior to the sampling, using a Buck calibrator.

Air Monitoring Study

The industrial hygiene air monitoring of the aquatic plant control spray operation started in the morning by meeting with the employees, who were selected for testing, to explain what the sampling process consisted of and to answer any questions.

The selected field crews were mobilized to the designated spray area to begin the spray operation using airboats. The aquatic plant control herbicide spray operations began using normal routine practices. The spray operations are generally conducted using a two (2) man crew, one sprayer and one boat driver. A Honda and Hypro D-30 spray pump configuration is utilized, using a D-10 orifice in a fan nozzle spray gun.

While spraying, the airboats normally operate at a low idle speed between 600 - 1,000 rpm, allowing the sprayer to fully control the application of the chemical product.

The capture medium was placed on the employees tyvek coverall lapel, adjacent to the breathing zone area. The air pump and teflon tubing were placed under the tyvek suit for protection from potential overspray.

The spray operations and the air

Table 1. 2,4-D AIR MONITORING STUDY RESULTS

JOB	DATE	DURATION (MINUTES)	AIR FLOW RATE (LPM)[1]	AIR VOLUME (LITERS)	2,4-D CONCENTRATION (mg/m^3)
Sprayer	08/22/88	388	1.29	500.52	<0.041
Driver	08/22/88	295	1.25	368.75	<0.056
Driver	08/23/88	264	1.10	290.40	<0.071
Driver	08/23/88	391	1.22	477.02	<0.043
Sprayer	08/23/88	409	1.23	503.07	<.043
Sprayer	08/29/90	270	1.93	521.4	BDL[2]
Driver	08/29/90	276	2.10	580.4	BDL
Sprayer	09/23/93	144	1.20	172.1	<0.10
Sprayer	09/23/93	120	1.20	143.4	<0.12
Driver	09/23/93	134	1.13	151.7	<0.12

[1]Liters/minute
[2]Below Detectable Levels

Table 2. DIQUAT AIR MONITORING STUDY RESULTS

JOB	DATE	DURATION (MINUTES)	AIR FLOW RATE (LPM)[1]	AIR VOLUME (LITERS)	2,4-D CONCEN-TRATION (mg/m^3)
Driver	08/22/88	386	1.68	648.48	<0.01
Sprayer	08/22/88	57	1.76	100.32	<0.08
Sprayer	08/23/88	422	1.68	708.96	<0.01
Sprayer	08/23/88	397	1.72	682.84	<0.01
Driver	08/23/88	155	1.76	272.80	<0.03
Driver	02/06/89	386	2.98	1150.28	<0.014
Sprayer	02/06/89	383	2.95	1129.85	<0.014
Sprayer	08/29/90	279	1.83	509.5	BDL[2]
Driver	08/29/90	277	2.02	560.1	BDL
Sprayer	09/23/93	139	1.19	165.3	<0.023
Sprayer	09/23/93	128	1.19	152.2	<0.025
Driver	09/23/93	140	1.18	165.8	<0.023
Driver	09/23/93	123	1.18	145.7	<0.026

[1]Liters/minute
[2]Below Detectable Levels

monitoring pumps were continuously monitored by visually observing the airboats from an inspection boat, and periodically inspecting the air pumps/filter cassettes for any malfunction.

Upon completion of the monitoring period, the air sample capture medium was removed and properly secured. The air pumps were post calibrated using a Buck calibrator. Any air pump variations, which exceeded the allowable flow rate difference of approximatley 10 percent from the pre to post calibration, were discarded. For every air test study, two (2) quality control blank samples were provided for validity/quality assurance purposes.

Sampling Results

Table 1 provides the 2,4-D sampling data results and identifies sampling date, flow rate, time duration and results in milligram of 2,4-D per cubic meter of air (mg/m^3).

Table 2 provides the diquat sampling date results and identifies the sampling data, flow rate, time duration, and results in milligram of diquat per cubic meter of air (mg/m^3).

Exposure Limits

The Occupational Safety and Health Administration's (OSHA) permissable exposure limit (PEL) is 10mg/m^3 for 2, 4-D and 0.5 mg/m^3 for diquat for an 8-hour work day. These PELs are government mandated levels which may not be exceeded. The American Conference of Governmental Industrial Hygienists (ACGIH) have also published exposure guidelines, called "Threshold Limit Values (TLVs)". The TLVs are considered guidelines. The ACGIH TLVs for 2, 4-D and diquat, are identical to the OSHA PELs.

Study Analysis/Conclusion

Based upon these air monitoring studies, concentrations of 2,4-D and diquat are below detectable levels for both the airboat sprayer and driver. Therefore, the employees should not suffer any adverse health affects from these operations if conditions remain the same as they were during the studies.

The reason why the airborne concentrations were below the permissible exposure level and threshold limit values during this evaluation may be due to the following factors:

- The concentrations of chemicals dispelled out of the spray nozzle was below 1 percent.
- The application technique of spraying from the side while the boat is operating at idle speed, allows the chemical spray to be directed away from both the sprayer and boat operator.
- During spray operations, the slow idle speed of the boat coupled with prevailing winds may combine to create a dilution/ventilation system where the spray mist (chemical) is pulled away from the user's breathing zone.

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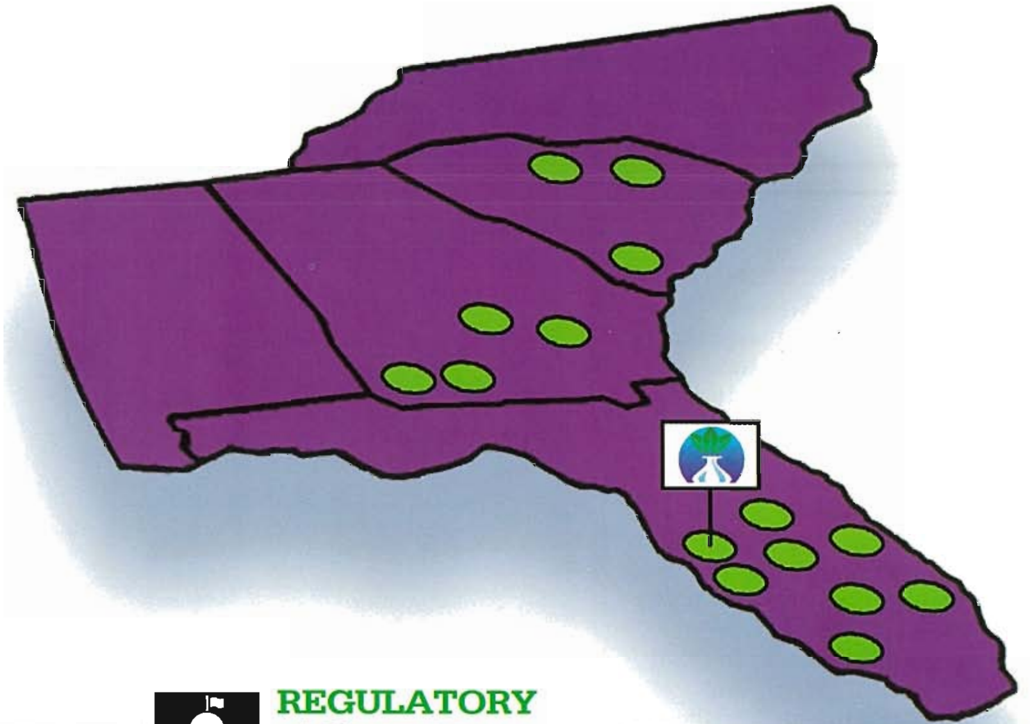

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Evaluation of Several Herbicides and Application Techniques for the Control of Brazilian Pepper

by
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Environmental Scientist and Environmental Scientist
Vegetation Management Division
South Florida Water Management District

Figure 1. Typical monoculture of Brazilian pepper, which has completely displaced native, wetland vegetation in Palm Beach Co., Florida.

INTRODUCTION

Brazilian pepper (*Schinus terebinthifolious Raddi*), a large shrub native to South America, has become an aggressive woody weed in southern Florida. It is a pioneer of disturbed sites such as highway and canal rights-of-way, fallow fields, and drained bald cypress stands, but is also invading undisturbed natural ecosystems (Woodall 1982). The aggressive nature of this woody exotic shrub seriously threatens species diversity in many of South Florida's native plant communities (Figure 1). Brazilian pepper stands often include plants in the early stages of colonization. Consequently, the potential effects of control methods on native, non-target vegetation must be considered.

Many land managers are seeking methods to eradicate this exotic pest in Florida. The South Florida Water Management District (District) currently manages several Brazilian pepper infested areas. District staff recognize the threat Brazilian pepper invasions pose in natural areas, and are actively involved in searching for optimum management solutions. The management of Brazilian pepper requires control techniques that target individual trees without affecting desirable species. Because of the ways in which herbicides affect the phisiology of all plants, many products are not target specific. Available herbicides applied using commonly broadcast application methods tend to be less species specific. However, several new application techniques, modification of older methods, and the use of certain herbicides offer promise to contain the expansion of this pest plant without injury to native species. This study was designed to evaluate these techniques with several herbicides to determine their effectiveness on Brazilian pepper. The study was conducted at the Alico property, near Immokalee, Florida. This property is part of the Florida Save-Our-Rivers program and is a component of the Corkscrew Regional Ecosystem Watershed located in north-east Collier County.

MATERIALS AND METHODS

The treatment location was infested with approximately 18 acres of Brazilian pepper. Prior to treatment application, parallel trails were established through the stand with a D4H crawler tractor to improve access. The resulting strips of Brazilian pepper were treated with the various combinations of herbicides and application techniques listed in table 1. Application techniques included foliar, basal bark, basal soil, and direct tree injection with E-Z-JECT® capsules and FICSAN® plugs. Langeland (1990) provides a complete description of these application methods. The treatment plots were heavily infested with Brazilian pepper, generally very dense and consisting of numerous individual trees which were multi-stemmed. Some of the plots were entirely covered with Brazilian pepper while other sites contained some scattered wax myrtle and cabbage palm.

The corresponding treatment number of E-Z-JECT® capsules were injected into the bark of each stem. The E-Z-JECT® system uses a five-foot long, spring-loaded, telescoping

Table 1. Herbicide treatments by application method.

METHOD[1]	HERBICIDE	RATE
EZJECT®	RODEO® (glyphosate 83.5%)	1 capsule @ 2 inch intervals
	RODEO® (glyphosate 83.5%)	1 capsule @ 4 inch intervals
	RODEO® (glyphosate 83.5%)	1 capsule @ 8 inch intervals
FICSAN®	SPIKE® (tebuthiron 80%)	1 capsule @ 3 inch intervals
	SPIKE® (tebuthiron 80%)	1 capsule @ 6 inch intervals
	SPIKE® (tebuthiron 80%)	1 capsule @ 12 inch intervals
	VELPAR® (hexazinone 90%)	1 capsule @ 3 inch intervals
	VELPAR® (hexazinone 90%)	1 capsule @ 6 inch intervals
	VELPAR® (hexazinone 90%)	1 capsule @ 12 inch intervals
Basal Soil	SPIKE® (tebuthiuron 40% pellet)	0.25 ounces / 6 inch BSD[2]
	SPIKE® (tebuthiuron 40% pellet)	0.5 ounces / 6 inch BSD
	SPIKE® (tebuthiuron 40% pellet)	1 ounce / 6 inch BSD
	VELPAR® (hexazinone 25% liq.)	2 milliliters / every 2 inches BSD
	VELPAR® (hexazinone 25% liq.)	4 milliliters / every 2 inches BSD
	VELPAR® (hexazinone 25% liq.)	8 milliliters / every 2 inches BSD
Basal Bark	GARLON 4® (triclopyr 44.3%)	1:4 oil ratio @ 0.1 oz inch BSD
	GARLON 4® (triclopyr 44.3%)	1:4 oil ratio @ 0.25 oz inch BSD
	GARLON 4® (triclopyr 44.3%)	1:4 oil ratio @ 0.5 oz inch BSD
Foliar	ARSENAL® (imazapyr 22.6%)	0.5% solution[3]
	ARSENAL® (imazapyr 22.6%)	1.0% solution
	GARLON 3A® (triclopyr 31.8%)	1.5% solution
	GARLON 3A® (triclopyr 31.8%)	3.0% solution
	RODEO® (glyphosate 53.8%)	0.5% solution
	RODEO® (glyphosate 53.8%)	1.5% solution

[1] EZJECT® Injection ammo is preformulated with an 83.5% formulation of Glyphosate, and FICSAN® Injection plugs are pre-formulated with a 90% formulation of hexazinone or an 80% formulation of tebuthiuron.
[2] BSD = Basal stem diameter
[3] Half a pint of X77 and 8oz of submerge was added to each 50 gallons of herbicide solution in all foliar tretment. Each Brazilian pepper tree in each plot was sprayed to wet.

barrel to inject 22-caliber cartridges into the bark of the tree. Each capsule is filled with a waxy formulation of herbicide which slowly melts with increased temperatures and releases the herbicide. In another treatment, FICSAN plugs were placed in small openings, created with a hollow-core tipped hammer, around the circumference of each stem. These plugs are made of plastic and are specially designed to rupture from the inside when hammered into the opening, releasing herbicide into the tree (Laroche, 1992). Foliar applications were made with a truck mounted sprayer. The appropriate amount of each herbicide was diluted in 50 gallons of water and the resulting solution was sprayed over the foliage with a handgun until the foliage was wet. Foliar applications were directed to each individual tree in each plot to minimize contact with non-target vegetation. Basal soil treatments were made with a backpack sprayer by applying the appropriate amount of undiluted herbicide on the soil around the base of each stem. SPIKE 40P was applied by hand-throwing the appropriate amount of pellets around the base of each tree. Basal bark applications were made with a backpack sprayer by applying the appropriate amount of herbicide directly onto the bark around the circumferance of each stem. The herbicide was diluted in diesel oil to facilitate penetration of the bark. All treatments were applied on March 16 and 17, 1992.

On March 11, 1993, one year later, each of the various treatments were evaluated by four evaluators. Ten trees in each treatment were visually rated by each of the four evaluators. Percent mortality or defoliation was used to determine the effect of each treatment on Brazilian pepper. Resprouting from the base and roots was also considered in the evaluation of each plot.

RESULTS AND DISCUSSION

Neither E-Z-JECT treatments of 1 shell at 4 or 8 inch intervals nor any FICSAN plug treatments produced acceptable control. Herbicide symptoms were apparent in these treatments but, none of the trees were defoliated. In the E-Z-JECT treatment of 1 shell per 2 inch intervals the trees on the perimeter of the plot were defoliated, while trees in the interior were not affected. After close inspection of the capsules, it was determined that, for the interior trees in the plot, the herbicide remained in the shells. Comparatively, the shells on the trees along the perimeter of the plot were completely empty. Because of the dense shading under the Brazilian pepper canopy and the moist, humid conditions in this wetland, it is possible that the temperature under the canopy was not warm enough to melt the waxy herbicide formulation within the shells. The trees at the perimeter of the plot were exposed to lower humidity and the heat of direct sunlight.

Both the E-Z-JECT and the FICSAN plug systems of application were cumbersome and difficult to use in this situation because of the dense, low-growing branches as well as the multiple-stem growth characteristic of this tree. The three herbicides used in these systems are usually effective at killing Brazilian pepper when applied using conventional foliar methods of application. The difficulty encountered in the placement of the capsules may have contributed to the low effectiveness. In other situations, where tree density is lower and the canopy is higher from the ground these injection systems may be useful techniques.

Foliar application of ARSENAL or GARLON 3A resulted in greater than 90% control at both rates, i.e., 0.5 and 10% ARSENAL solutions and 1.5 and 3.0% GARLON 3A solutions (Figure 2-A). Foliar application of RODEO in a 1.0% solution defoliated only 32 percent of the trees. The lower rate of 0.5% was not effective. RODEO has been reported to be effective on Brazilian pepper trees, however, efficacy is dependent on time of application. According to Vandiver (1993, personal communication), RODEO tends to be more effective on Brazilian pepper when applied in December in South Florida. Because RODEO was applied in March in this study, ideal effectiveness may not have been possible. Non target vegetation was also

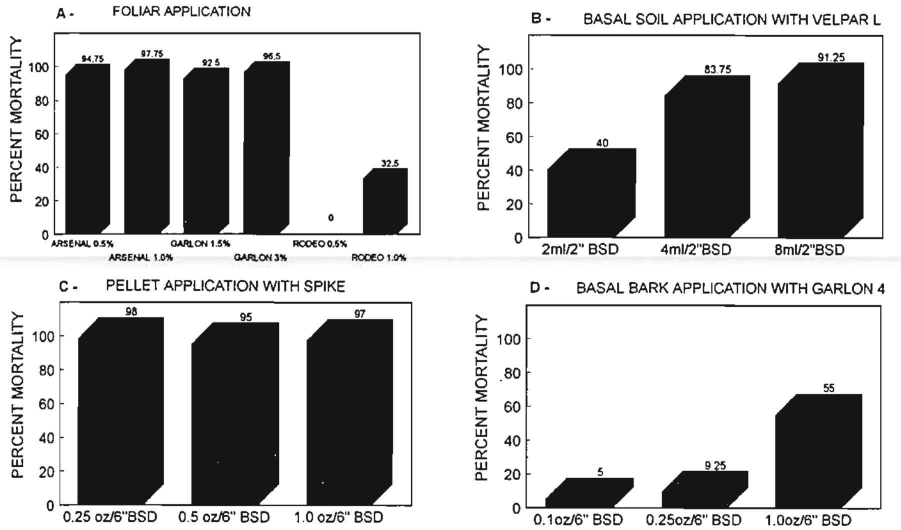

Figure 2. Brazilian pepper response to various herbicides and application methods.

affected in all the foliar treatments. However, wax myrtle was somewhat resistant to foliar application of ARSENAL.

Basal soil application of both VELPAR L and SPIKE 40P were very effective at controlling Brazilian pepper. Undiluted VELPAR L applications at 4 and 8 milliliters per 2-inch BSD resulted in 83 and 91% control respectively, (Figure 2-B). The lower rate of 2 milliliters per 2-inch BSD was not effective. All three rates of SPIKE 40P resulted in greater than 95% control (Figure 2-C). Although the impacts on non-target species were not evaluated, damage to adjacent shrubs and trees was apparent in these treatments.

Basal bark treatments using GARLON 4 in an oil based solution is very effective against Brazilian pepper trees. Typical application rates consist of relatively high volumes of a mixture of herbicide (5 %) in diesel, vegetable or mineral oil (Schneider et., all, 1991). In this type of treatment the herbicide/oil mix is applied directly to the bark in a one-foot band around the circumference of the tree just above the ground level. When treating dense stands of Brazilian pepper it is very difficult for applicators to spray around the circumference of multiple-stemmed trees while carrying a back-pack sprayer. The dense understory branches greatly inhibits access. In this study the objective was to use a higher herbicide concentration (25%) in the oil mix with lower dosages to reduce the need for spraying completely around the circumference of each stem. The basal bark treatments were not very effective; however, improved effectiveness was observed with the higher dosage treatments (Figure 2-D). One ounce of 25 percent herbicide/oil mix sprayed for every 6 inches of basal stem diameter (BSD) resulted in 61 percent control, while 0.1 and 0.25 ounces resulted in very little or no control. To determine if an even higher dosage (e.g. 2 ounces of mix per 6-inch BSD) would give complete control, this test should be repeated.

CONCLUSION

This study indicates that several herbicides can effectively control Brazilian pepper. The degree of damage to non target species is partly dependent on method of application. The injection systems provided the least amount of non-target damage, but are impractical in dense stands of Brazilian pepper. Generally, site conditions will often determine what combination of herbicide and method of application to use for the control of this pest plant in South Florida.

ACKNOWLEDGEMENTS

The authors wish to thank Dan Thayer, Mike Bodle and the Clewiston Field Station Vegetation Management personnel, of the South Florida Water Management District, for their support and cooperation in this project.

References available upon request.

AquaVine

MEETINGS

UF, IFAS, CAP Aquatic Plant Management Workshop and Research Review

The IFAS Center for Aquatic Plants will host a combined Aquatic Plant Management Workshop and Research Review on June 7th and 8th at the Holiday Inn West (the one on I-75 and Newberry Road) in Gainesville. We'll have an informal, pool-side barbecue at the hotel in the evening. Make plans now and watch your mail for further details.

APMS 1994 Annual Meeting

The Aquatic Plant Management Society will hold it's 34th Annual Meeting July 10-13, 1994 at the Hilton Palacio del Rio in San Antonio, Texas. For additional information contact Joe Zolczynski at 205/626-5153.

FAPMS Annual Meeting

Our 1994 annual meeting will be held October 11-14 at the Ramada Hotel Resort, Florida Center in Orlando. Alison Fox, this year's Program Chair will begin accepting titles at any time at 904/392-1808 (sc 622-1808).

Letter to the Editor

The Department of Environmental Protection, Bureau of Aquatic Plant Management must take exception to the piece entitled "There Goes the Trust Fund" which appeared in "AquaVine" in the Winter 1993 issue of Aquatics, and would ask you to print this "Letter to the Editor'" in the next available issue. The piece was both inaccurate and misleading.

In the 1992 session, the Legislature increased the amount of money transferred from the Gas Tax Collection Trust Fund into the Aquatic Plant Control Trust Fund from $3.8 million to $6.3 million. Out of the total increase of $2.5 million, $1 million was mandated to be spent on melaleuca. The Legislature viewed that $1 million increase as being specifically for melaleuca control.

Please remember, the Bureau did not designate melaleuca as an aquatic plant, the Florida Legislature did. Prior to 1992, the Bureau had promised that it would not take funds from the existing aquatic plant control program for melaleuca control, until the Legislature provided funds specifically for that purpose—and the Bureau kept that promise. Also, understand the Bureau does not control the mandates of the Legislature, but must abide by them just as we must abide by all other laws.

Tom C. Brown, Chief

Bureau of Aquatic Plant Management

ON THE MOVE

Phil Chiocchio Heads to Sarasota

Phil Chiocchio, known to many of us simply as Phillipio, quickly rose to stardom in FAPMS with his blockbuster smash hit video programs "Johnny Spraygood" and "Do the Adjuvant." As Videographer, Phil has been instrumental in developing all Center for Aquatic Plants videotape productions during the last five years. We will miss Phil, who leaves us with these words:

"I would like to thank everyone in FAPMS for helping me during the last five years in the production of the instructional videos, stage shows, Plant identification workshops and music videos. It has been a great adventure that I will always cherish.

My new career path takes me to the Ringling School of Art and Design in Sarasota in the Computer Animation Department, as the Coordinator of Video.

I will also be working with Ringling Multi-Media in the creation of additional videos. If I can be of any assistance to any of you, I would love to help. Again, thanks for all the fun."

New Position for Alison Fox

Before you panic - no Alison's not leaving. She has been reappointed from her former position of Postdoctoral Associate to Research Assistant Professor with the IFAS Department of Agronomy. Congratulations Alison. Alison's office number is 904/392-1808.

Dr. Joe Joyce Named to New Position

It's official. Dr. (Joe) Joyce has moved to a higher level in IFAS administration. Joe has provided us with his dedicated leadership as director of the Center for Aquatic plants for 12 years. He has been in a dual role for the last five years, being Director of the Center for Natural Resources as well. For the last six months he has been serving as Interum Dean for Research. Recently, Joe applied for the position of Associate Vice President for Agriculture and Natural Resources, and Vice President Davidson announced that he was selected for this assignment effective February 11, 1994.

This is a tremendous opportunity for Joe, and he will serve IFAS well in his new position, but we will, of course, miss him at the Center. Joe will remain as Secretary/Treasurer of the FAPMS Scholarship and Research Foundation and he has promised to "stay active in the Society because everybody's got to have their roots."

CAP to Begin Search for New Director

IFAS Vice President for Agricultural Affairs, Jim Davidson will soon appoint a Search and Screen Committee to conduct a national search for a new Director of the Center for Aquatic Plants. Until the new Director is searched, screened, and on board, Dr. Haller will remain in the acting role as Center Director.

Steve Smith Coordinates District's Weed Control on Lake Okeechobee

Due to rising concerns about aquatic plant management on Lake Okeechobee, the South Florida Water Management District has moved Steve Smith, Senior Scientific Technician, from the main office in West Palm Beach to the Okeechobee Service Center. His principle responsibility is to coordinate aquatic plant control treatments on the lake with the COE, District Field Stations, and other State Agencies. He is also working to increase public awareness about the aquatic plant management program, especially with anglers.

Wendy Andrew Named to Endangered Species Task Force

Wendy Andrew is now the FAPMS representative to the FDACS Endangered Species Task Force. The Task Force is presently working with FDACS, EPA, and USFWS to develop programs that meet the Endangered Species Act requirements as they relate to pesticide usage. The programs being developed <u>will</u> have impacts on how we do the business of aquatic plant management - both governmental and commercial. Wendy will be providing the Society with updates on these developments. If you have questions or comments, please get in touch with her.

1994 Scholarship Grant

The South Carolina Aquatic Plant Management Society is once again seeking applications for its annual scholarship grant. If an appropriate applicant is found, the Society will award its fourth annual $1000 grant at its Annual Meeting in August, 1994. Grant funds may be used by the recipient to cover any costs associated with education and research activities.

Eligible applicants must be enrolled as full time undergraduate or graduate students in an accredited four year college or university in the United States. Coursework or research in the area of aquatic plant management or aquatic ecology related to the Southeast is also required.

Applicants must be received no later than June 1, 1994 and will be evaluated on the basis of relevant test scores (ACT, SAT, GRE, etc.), high school and/or college grades, quality and relevance of research or coursework, a proposed budget, information obtained from references, and other related considerations. Other factors being equal, preference will be given to applicants enrolled in Southeastern and South Carolina academic institutions.

Persons interested in applying for the scholarship grant should contact Danny Johnson, S.C. Water Resources Commission, 1201 Main Street, Suite 1100, Columbia, South Carolina 29201, phone (803) 737-0800 for additional information on application procedures.

IN MEMORIUM

Mr. Bob Gates died January 13, 1994 after a brief illness. Bob worked in aquatic plant management for 14 years as Director of Field Operations for the Southwest Florida Water Management District. He was a Charter Member of the Florida Aquatic Plant Management Society, and served on the Board of Directors. He was an active member of the Hyacinth Control Society and later the Aquatic Plant Management Society (APMS), for which he served as a Director (1969-70), Secretary/Treasurer (1970-71), and President (1971-72), and he was awarded Honorary Membership in 1984. I personally remember Bob for his friendliness, which made me feel like "I belonged" at the first APMS meeting which I attended.

In lieu of flowers, the family requests contributions be made to the "Summer Camp Scholarship Fund for Children," c/o Metropolitan Ministries, 2002 N. Florida Avenue, Tampa, FL 33602.

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