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**Letter to the Editor**

A global awareness is developing regarding the environmental and economic costs precipitated by invasive exotic plants and animals. Many states and foreign nations have begun the costly process of removing the most invasive exotics from public lands as a step toward restoring natural plant and animal diversities.

We in Florida should be proud of the leadership role we have played in waterhyacinth management. The maintenance control philosophy is being adopted by many groups just beginning invasive exotic plant and animal control programs. However, Florida's public lands have been invaded literally by hundreds of exotic plants and animals. Because the science of invasive exotic species impacts is so new, only a decade or so old, most Floridians do not understand or do not know that problems exist. We, as aquatic plant managers, must lead through education and by example to preserve the public waters entrusted to our care. We can no longer introduce invasive exotic species or allow these contaminants to expand for the benefit of special interest. We must balance all of the impacts, current and future, of our actions (or inactions) on the environment. There are still many who would trade future environmental and economic costs for the benefits created today by the invasive waterhyacinth and hydrilla. Most of our governmental leaders still do not understand the repercussions of inadequate funding to manage invasive exotics.

The wake-up alarm is poised to ring on October 1, 1994. During the past two years, the Cooperative Aquatic Plant Management Program has operated with a \$9.0 million budget, more than \$5.0 million of which was spent on hydrilla management each year. However even this level of funding was inadequate. Hydrilla expanded by 50% to cover 75,000 acres of public waterways in 1993. For fiscal year 1994-1995, the Legislature has authorized slightly less than \$6.0 million for aquatic plant management.

**Section 212.69(1) (a), Florida Statutes**, mandates that the Department spend \$1.0 million on melaleuca control each year. The average cost to control waterhyacinth and waterlettuce under the Cooperative Program over the past five years has been about \$1.5 million. Minor plant control, to maintain boat trails and access points, cost an average \$370,000 during the same period. If these estimated costs are deducted from the fiscal year 1994-1995 aquatic plant control budget, this would leave approximately \$3.0 million for hydrilla control. In the annual report to the Governor and Cabinet, the Department estimated that nearly \$10.0 million are needed for appropriate hydrilla management during fiscal year 1994-1995.

With this kind of funding gap, we anticipate that hydrilla will go untreated in many waterbodies until funding is significantly increased. In the meantime, we as managers of public waters should do all we can to keep hydrilla populations as low as possible and educate the public in the ultimate dangers of this invasive exotic plant. To do otherwise, would be both environmentally and economically irresponsible.

Jeff Schardt



**Hallelujah!**  
It's summertime.  
Photo of "Swimm'n hole  
on Santa Fe River"  
by Nancy Allen

**Aquatics**

Summer 1994/Vol. 16, No. 2



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## Invasion of the Tussocks



Figure 1. One of two Adirondock Inc. harvesters removing nine acres of tussocks from Coon Lake from the Alligator Chain in eastern Osceola County.

by

**Bob Hujik**

**Florida Game and Freshwater Fish Commission**

**Kissimmee, Florida**

### **Background**

The Alligator Chain of Lakes, located in eastern Osceola County, is made up of six lakes ranging in size from 225 acres (Coon Lake) to 5,100 acres (Alligator Lake). The Chain is connected by a series of canals, and water levels are regulated by the South Florida Water Management District (SFWMD).

Florida's rainfall pattern historically produced a wide range of water level fluctuations in the Alligator Chain. Aquatic plant and animal communities adapted to high- and low-water periods. Lake levels fluctuated as much as 7 feet on an annual basis. However, since implementation of flood control practices in the mid-1960's, annual

lake level fluctuations have been strictly regulated within a 2 foot range. Restrictive water level fluctuation regimes have encouraged the growth of dense monotypic bands of pickerelweed (*Pontederia cordata*), cattail (*Typha* spp.), American cupscale grass (*Sacciolepis striata*) and burhead sedge (*Scirpus cubensis*). Most of the growth has occurred within the regulated low-pool stage of the lakes' shallow littoral zone. These bands of vegetation, referred to as tussocks, root in the loose bottom substrate at low-pool stage and float at higher lake stages. Tussocks impede water exchange in the shallow littoral areas, decrease

habitat available for fish reproduction and interfere with other recreational uses. If the present water level schedule remains unchanged and/or nutrient loading as a result of development along the shoreline continues to increase, organic material and dense bands of vegetation will continue to build up around the lakes and severely impact productivity. The diversity and abundance of fish, invertebrates and aquatic plant communities in the Alligator Chain have already begun a slow decline. To determine if the trend could be reversed, an experimental aquatic plant harvesting/revegetation program was implemented in 1992 on lakes Coon

# Clearly, it just makes good sense to be careful when controlling aquatic weeds!

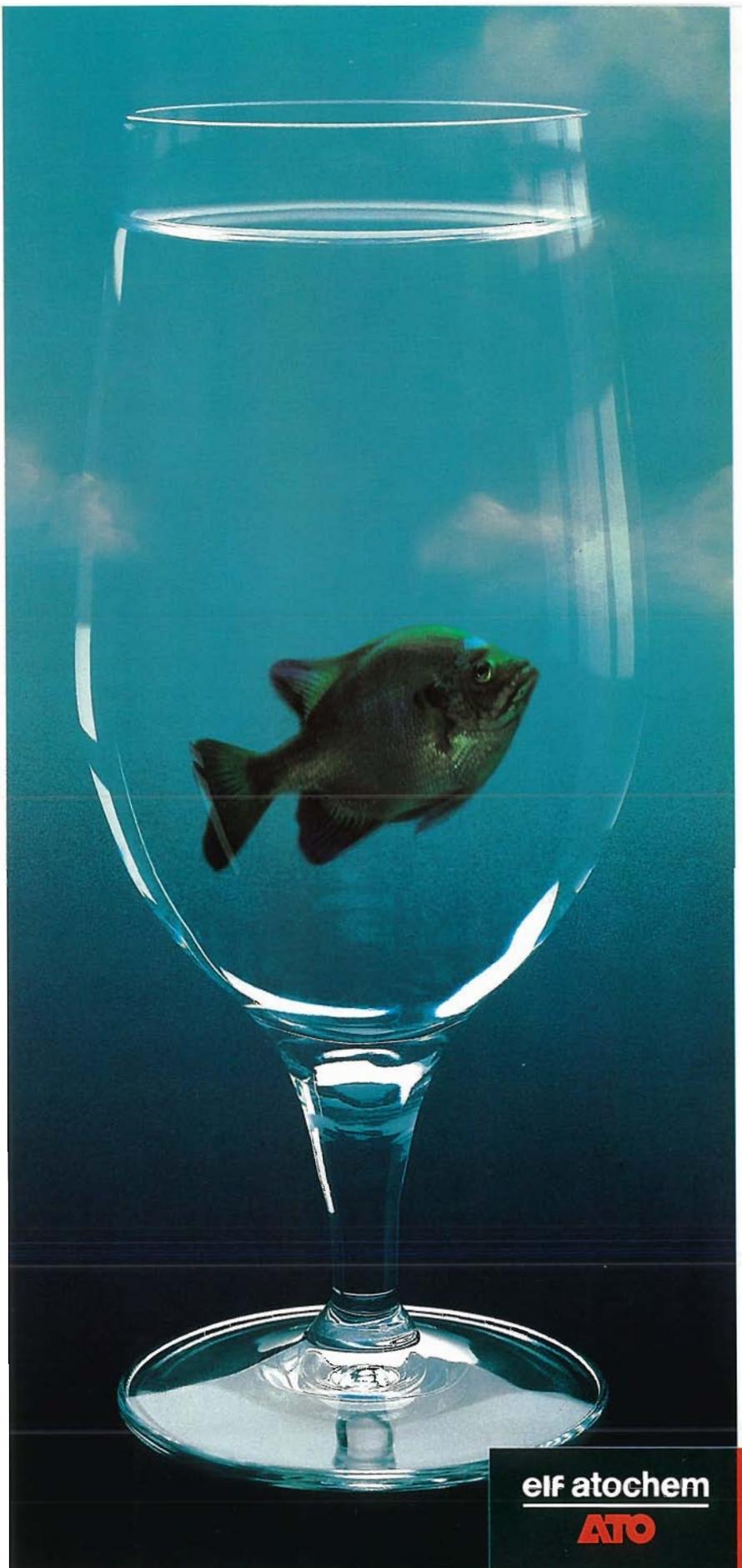
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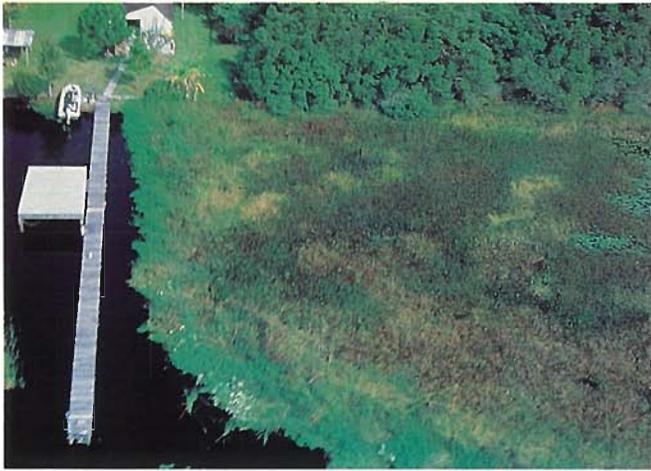


Figure 2. A portion of Coon Lake before (A) and after (B) removal of nine acres of tussocks. Note comparison of open water, before and after harvesting, in reference to dock.

and Center (600 acres) and continued during 1993 on Lake Center.

**The 1992 Experimental Project**

On 20 January 1992 Adirondack Harvesters Inc. began removing nine acres of floating tussocks from Coon Lake (Figure 1). The tussock band averaged 70 feet wide and encompassed three-quarters of the lake's shoreline. The tussocks were predominantly pickerelweed, burhead sedge, water primrose (*Ludwigia* spp.) and organic muck. Tussocks were removed with mechanical harvesters (one 8-foot and one 10-foot), off-loaded onto a 10-foot shore conveyor and trucked to adjacent upland disposal sites. A SFWMD canal bank and county right-of-way were used for disposal. The material was left to decompose. The mechanical harvesters were unable to work in water less than 2 feet deep therefore, harvesting was done when lake levels were at high-pool stage (64 ft msl) so the maximum amount of tussock material could be removed. Crews worked 7 days/week and were rotated weekly to complete this part of the project by 23 March 1992 (Figure 2).

On 24 March 1992, harvesting began on a 5-acre section of Lake Center. Since lakes Coon and Center are connected by a canal, only part of a day was used to move equipment to Lake Center. Tussocks at the new site consisted mainly of burhead sedge, American cupscale grass, water primrose and cattail; the average width of this

tussock band was 150 feet.

The Florida Game and Fresh Water Fish Commission (GFC) and SFWMD cost shared \$100,000 for the experimental project. Two homeowners on Coon Lake provided funding to Adirondack Harvesters Inc. for 0.1 acres of tussocks to be removed in front of their residences. In addition, ten lakefront property owners payed Adirondack Harvesters Inc. to harvest approximately one acre of tussocks at a cost of \$1,000. All work was completed by 11 April 1992.

No noxious plant regrowth was observed on the restored areas of either lake one year after mechanical harvesting. Since it took 15 to 20 years of stabilized water levels for the tussocks to form, regrowth should not be apparent one year later. However, small areas of sparse maidencane (*Panicum hemitomon*) and spatterdock (*Nuphar luteum*) have regrown on the restored areas. Apparently the tussocks were suppressing the growth of those plants. Cattails, that were cut off a maximum of 12 inches above the lake bottom, showed no new growth. Bottom organic sediments that measured up to 12 inches deep after removal, were only 0.5 inches to 3 inches in depth one year later. It appears that wave action in harvested littoral areas flushed the sediments lakeward, leaving hard sandy substrate behind.

Cost per acre estimates averaged

\$9,300/acre for Coon Lake and \$3,700/acre for Lake Center. Lower cost estimates for Lake Center were primarily due to the shorter travel distance between the work site and the shoreline conveyor. The physical density of the tussock directly influenced the cost per acre. The burhead sedge/American cupscale grass tussocks on Lake Center were less dense and much easier to harvest than the pickerelweed tussocks on Coon Lake.

In June 1992, project personnel planted 2,200 giant bulrush on the restored areas of Coon Lake (2,000 plants) and Lake Center (200 plants). An additional 200 bulrush plants were given to the Alligator Chain Homeowners Association to be planted throughout the Chain. All bulrush showed signs of regrowth, averaging three stems of new growth per planted stem. Some plants had as many as 14 new stems of growth.

**The 1993 Aquatic Plant Harvesting Project**

On January 11, 1993, Adirondack Harvesters Inc. again began removing 19 acres of floating tussocks from Lake Center. A total funding package of \$135,000 from the GFC and SFWMD was allocated for the project. Three harvesters were used (one 8-foot and two 10-footers) instead of two to increase the rate of removal. Harvesting procedures were the same as described in the 1992 project. Disposal sites within

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one mile of the off-loading site were difficult to find. An area of pine/oak scrub was finally located and used. The tussock band (150 ft wide) was comprised of burhead sedge, water primrose and pickerelweed that were rooted in floating organic muck. Cattail, which was rooted to the bottom, and American cupscale grass, which was floating, formed the outside edge of the tussock. The project was completed 18 March 1993.

Areas of sparse spatterdock and maidencane have regrown on these restored area. Again, as on Coon Lake, the growth of these native vegetation types was suppressed by the tussock. No regrowth of the cattails was observed. The roots were examined in the field and appeared dead. A major wind storm, that moved through Central Florida on 13 March 1993, pushed organic bottom material from the restored areas on to dry ground, thus bottom sediment depths averaged only 2 inches.

Cost estimates to harvest tussocks averaged \$5,200/acre, almost 30% higher than the 1992 Lake Center estimates (\$3,700/acre). The higher cost estimate was primarily due to the fact that some work sites were on the opposite side of Lake Center; approximately 0.75 to 1 mile from the shoreline conveyor.

In July 1993, an additional 2,200 bulrush plants were planted on Lake Center and 300 more on Coon Lake by GFC and SFWMD personnel. Also, 250 bulrush plants were given to the Alligator Chain Homeowners Association to be planted throughout the Chain. During August 1993, 150 eel-grass (*Vallisneria* spp.) plants were planted on a restored area in Coon Lake. This area was marked and will be monitored to determine growth.

Parameters such as water quality, dissolved oxygen and sediment depths are being analyzed quarterly. Annual fish and vegetation surveys are also being conducted. This information will help evaluate the success of the project.

## Conclusions

Several factors such as proximity of off-loading sites to work sites, areas for disposal and time allowed for mechanical failure impact cost of harvesting operations. Off-loading sites close (< 1 mile) to the work site will keep project costs down. It was noted that during 1993 costs on Lake Center were much higher because of longer travel distance. It is important to locate off-loading areas that are deep enough ( $\geq 3$  ft) for the harvesters to maneuver up to the conveyor. Easy access areas where the water gets deep quickly, such as boat ramps or canal banks, work well.

Finding upland disposal areas close to the off-loading site for the tussock material is also important. In rural areas, owners of large parcels of land were targeted. Many landowners did not want tussock material on their properties even though it reduces 50% by

volume during the first year of drying. In metropolitan areas, landfills and/or areas specifically designated by the city or county could be used.

Finally, each project was hampered by mechanical breakdowns. At least two weeks were lost during each project because of mechanical failures.

Harvesting is a very practical lake restoration technique in smaller systems where travel time can be kept to a minimum. Future projects will depend on the availability of nearby disposal sites and funding. While drawdown/muck removal operations are less expensive than harvesting (\$2,000/acre vs. \$6,000/acre), it is often unfeasible or impossible to implement drawdowns when and where they are needed.

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# HIPPO GRASS: AN INVASIVE WARM-REGION AQUATIC GRASS

by

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Biological Scientist

Florida Department of Environmental Protection  
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## Introduction

Hippo grass (*Vossia cuspidata* Roxb.) is an invasive grass that grows in freshwater aquatic and wetland areas in warm regions of the world. Heavy growth of the plant often covers the margins of lakes and rivers in Africa, creating problems for water use and native biota (Lawson, 1970; Pierce and Opoku, 1971). Biologists, environmental groups, and others have indicated concern over the invasive nature of this plant. For example, Hall et al. (1971) state that "*Vossia* forms such a dense cover" that it can be difficult to traverse, and its thick stems make it "very difficult" to clear. Four years after the construction of a reservoir in Ghana, hippo grass and other aquatic plants started to cause a "weed problem... [and] continued to expand until... most of the lake's shallow water is infested... throughout most of the year" (Pierce and Opoku, 1971). The common name hippo grass relates to the plant's consumption by the hippopotamus. It is also commonly called um-soof (Ramey, 1990). Synonyms include *V. procera* Wall & Griff. and *Ischaemum cuspidatum* Roxb. (Ramey, 1990).

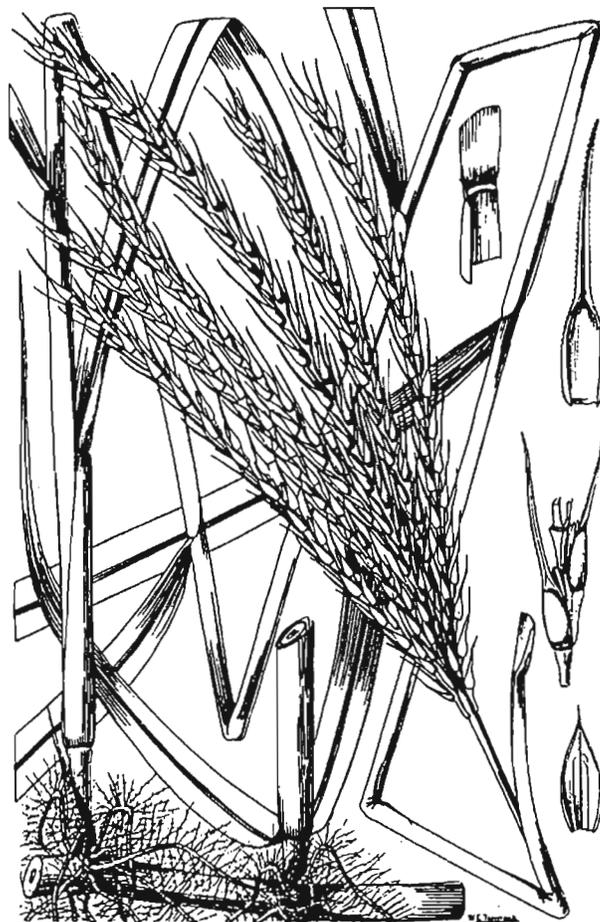


Figure 1. Hippo grass (*Vossia cuspidata*), is a perennial aquatic grass, with floating and submerged culms, which resembles rice. Reprinted from *Flora of Tropical East Africa*.

ous from Africa to Asia and is absent also from the new world, including Florida. Hippo grass is a dominant species in wetlands in Zambia and Sierra Leone (Hall et al., 1966; Chabwela and Siwela, 1986) and on margins of the Okavango River, Botswana (Ellery et al., 1990).

Reports do not list the presence of hippo grass in Florida public waters. For example, the species does not appear in *Aquatic and Wetland Plants of Southeastern United States* (Godfrey and Wooten, 1979); and Dr. L.C. Anderson of Florida State University is not aware of any domestic observations of the plant (pers. comm., 1992). In 1991, Schardt and Schmitz listed more than 100 aquatic plants from Florida public waters, but not hippo grass. It is listed as a Florida prohibited aquatic plant, and may not be possessed or imported to the state (under Florida Administrative Code 16C-52).

## Description and Identification

Hippo grass, the only member of the genus *Vossia*, is an emersed aquatic grass that resembles rice (Figure 1). It is a perennial plant with floating and submerged culms, rooting in shallow water or growing on ditchbanks, and sometimes forming dense mats on the water surface (Lazarides, 1980). Leaf blades are

## Distribution

Hippo grass apparently originated in Africa or Asia. It is widely distributed in tropical Africa, India, Burma, Thailand, and the Indo-Chinese peninsula (Lazarides, 1980). However, the species is not continu-

<sup>1</sup>Address: Formerly with the Bureau of Aquatic Plant Management, now with the Bureau of Mine Reclamation, DEP, 2041 E. Dirac Dr., Tallahassee

emersed, flat, and strap-like, with basal sheaths. They are up to 3 feet (0.9 m) long and 0.8 inch (2 cm) wide, with a pointed tip (Ramey, 1990). Stems are creeping, spongy, submersed or floating stolons, up to 20 feet (6 m) in length and 0.4 inch (1 cm) in diameter. Roots arise from the nodes. Inflorescences are infrequent, on single or palmate flower spikes. These spikes are 1 - 12 inches (2 - 30 cm) long, with three stamens per floret (Ramey, 1990; Clayton and Renvoize, 1982).

**Biology**

Hippo grass spreads rapidly by vegetative reproduction. In north Africa, vegetative growth continues throughout the year (Andrews, 1945). The plant establishes by rooting from the nodes of stems that wash ashore (Pierce and Opoku, 1971). The rhizome system of hippo grass permits explosive growth along freshwater shorelines (Pierce and Opoku, 1971).

A secondary means of reproduction is sexual. In north Africa, hippo grass flowers maximally at the end of November (Andrews, 1945). Seeds are dispersed by water and apparently by human earthmoving along edges of water bodies (Lubke et al., 1981). Hippo grass is considered a weed in several tropical regions of the world. It is "present" as a weed (Holm et al., 1979) in Bangladesh, the Sudan and Vietnam (i.e., it is present and behaves as a weed, but its rank of importance is unknown). Reasons for its invasiveness are given below.

Hippo grass can grow so rapidly that it is not killed by high water levels. In Volta Lake, Ghana, the water level starts to rise slowly when the plant is already established (Pierce and Opoku, 1971), and it is able to grow faster than the water rises.

A typical cross-section of vegetation from a swamp in north Africa consists of floating macrophytes such as waterhyacinth (*Eichhornia crassipes*) in deep water, vast amounts of hippo grass in the shallows, and emergent species at the shore (Denny, 1984). Along the Kafue River, relatively high natural levees are not flooded during hydrologically normal years, and are dominated by grasses such as

hippo grass (Chabwela and Ellenbroek, 1990; Msangi and Ellenbroek, 1990).

Hippo grass borders the margins of the upper Nile River, from shore to about 3.3 feet depth (1 m, Denny, 1984). Rhizomes anchor the plants into the substrate, in areas where current velocity approaches zero (El Moghraby et al., 1986). Furthermore, shoots and floating rhizomes spread over the water surface to produce a raft of vegetation 3.3 - 6.6 feet (1 - 2 m) high, covering water up to 15 feet (4.5 m) deep. Typical stands are so thick that hippo grass is unable to penetrate very far into them (Denny, 1984).

Hippo grass grows together with other species to form sudd, a troublesome dense aggregation of floating vegetation that is virtually impenetrable (Andrews, 1945; Hall et al., 1966). Thus the plant has a high pest potential for Florida. In Volta Lake, Ghana, it is reported to survive while floating free of land-anchorage,

but to not grow as vigorously as when rooted (Pierce and Opoku, 1971). It forms floating islands of 330 feet (100 m) in diameter on the edge of the littoral zone of Lake Chilwa, Malawi (Howard-Williams and Walker, 1974).

Hippo grass invades disturbed sites, including dredged river-edge spoils and recently constructed reservoirs (Obot and Mbagwu, 1986; Obot, 1986). On steep banks created by dredging of the Boro River in Botswana, hippo grass was one of the major colonizing plants (Lubke et al., 1981). Large areas of natural climax vegetation were covered by spoil heaps, creating drier, steeper banks which were thus not as readily invaded by native colonizers, but were invaded by hippo grass. "The loss of a number of aquatic habitats... has resulted in a drastic reduction in the diversity of plant species, which in turn results in the loss of faunal diversity. The change in available food for microfauna, insects,... fish, waterfowl and buck [ungulates] and the loss of suitable niches for animal life must have an adverse effect on

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the whole ecosystem" (Lubke et al., 1981).

Hippo grass thrives in a wide range of environmental conditions. In Malawi, it grows in marshland with heavy clay soil, in water-logged silty areas, and in tall-grass marshes that are inundated during the rainy season (Howard-Williams and Walker, 1974). Hippo grass is apparently not tolerant of salt conditions, since reported distributions are from freshwater habitats (e.g., Obot, 1989; Howard-Williams, 1972).

The warm climate of most of Florida would probably favor the growth of hippo grass. In Miami and Tampa, the mean daily minimum temperatures in January are 16 and 11 C, respectively, similar to Khartoum, north Africa, where the mean daily minimum temperature in January is 16 C (Muller, 1982). Comparison of these temperatures suggests that the species would not be temperature limited in south Florida and possibly central Florida (Gilbert, pers. comm., 1992).

**Importance**

Hippo grass has no known commercial value. It is not raised as

an aquarium plant nor as a terrestrial ornamental. Its only known value is as food for water buffalo and other ungulates (Lazarides, 1980).

In tropical regions, hippo grass indirectly increases human disease such as schistosomiasis. In the Volta Lake reservoir, Ghana, it grows in sheltered areas along the shoreline, providing a substrate and food for the snail that is one of the vectors of urinary schistosomiasis, which has consequently increased among people living along the shoreline (Ackermann et al., 1973).

The sudd mats formed by hippo grass and other plants sometimes result in decreased dissolved oxygen concentrations (Mitchell, 1969). In Africa, stable mats of giant salvinia (*Salvinia molesta*) provide a substratum for the growth of horizontal vegetative stolons of hippo grass, and the resulting floating islands have reduced oxygen concentrations beneath them.

Boat traffic, fishing, recreation, and canals are sometimes adversely affected by aquatic plants such as hippo grass (Pierce and Opoku, 1971). On Volta Lake, heavy aquatic plant growth has curtailed fishing in some of the lake's most potentially

productive fishing areas. In an irrigation system in north Africa, hippo grass forms floating mats that cover the whole width of minor canals (Madsen et al., 1988). The horizontal stolons also impede water flow, especially if other smaller plants become trapped, thus posing a threat to flood control.

**Management Options**

**Herbicides**

There is a dearth of published information on the control of hippo grass. Pierce and Opoku (1971) report that mechanical removal of shore brush followed by spraying of aquatic plants with fenac and diuron results in the removal of aquatic vegetation, including hippo grass. These herbicides are not legal for use in aquatic systems of Florida, but diuron can be used for treating the plant in terrestrial areas. It is possible that herbicidal methods used in controlling cattails (*Typha* spp.) may be effective on hippo grass in aquatic systems (e.g., glyphosate, K. Gilbert, pers. comm., 1992).

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**Mechanical**

Little information is available on the effects of mechanical control methods on hippo grass. On Lake Volta, six laborers and heavy farm equipment required 14 days to clear brush and aquatic plants from 7.3 acres of shoreline and shallow areas (Pierce and Opoku, 1971). Because this treatment was followed by herbicides, Pierce and Opoku (1971) did not speculate on the effects of mechanical clearing alone. Mechanical harvesting of hippo grass has limitations. Vegetative propagation by the plant increases the likelihood of the survival of nodal rootings, and makes it less vulnerable to mechanical and possibly herbicidal control. If hippo grass is introduced into Florida, it will be expensive to control. In Citrus County in 1985, the cost of harvesting floating islands of vegetation was \$918.75 per acre (\$2,270.20 per ha), using an Aquamarine H-650 aquatic plant harvester (Thayer and Ramey, 1986).

**Habitat Manipulation**

Habitat manipulation is not likely to control hippo grass. The species is tolerant of a wide range of habitats, from deepwater to shoreline. In Africa, stabilization of water levels by reservoir construction has resulted in large infestations. However, in areas that get frost, winter drawdown might damage this tropical plant. It is also possible that controlled burns could control it in some areas.

**Biological Control**

Cattle graze on hippo grass, so in appropriate areas, they might be used to decrease its abundance (Howard-Williams, 1975). Little if anything is known about possible arthropod biological controls of the plant. Monophagic biological control insects might be present in the plant's native home range in Africa or Asia, and could be sought there.

**Summary**

The invasive species, hippo grass, has spread through disturbed and undisturbed warm regions of Asia and Africa. If the plant is allowed to

enter Florida, it could come to dominate large areas, especially in south and possibly central parts of the state. The species poses a threat to natural systems where it could replace native plants that provide habitat and food for native fauna, and could also invade restoration sites, such as those constructed on spoils or in restored water bodies. If it does enter Florida, it should be detected and eradicated as quickly as possible.

**Acknowledgments**

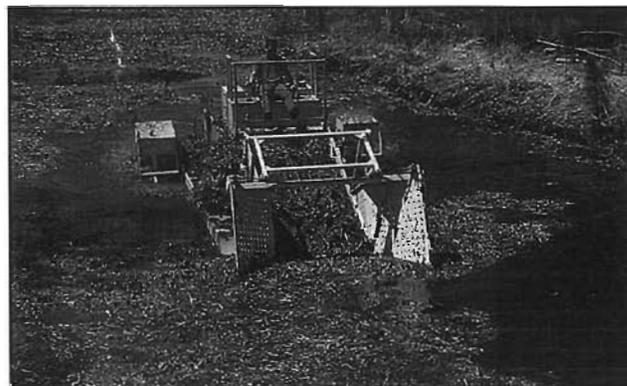
G. Jubinsky, R. Kipker, A. Leslie, W. Bartodziej, and M. Phillips of the Bureau of Aquatic Plant Management, and K. Gilbert of the Bureau of Wetland Resource Management provided valuable comments. K. Brown of the University of Florida Aquatic Plant Information Retrieval Service provided papers from the literature.

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# Keeping Track of Hydrilla

by

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## Introduction

In the 35 years since its introduction into the U.S., hydrilla has spread relentlessly. The original introduction, a dioecious female plant, is now established from Florida to California. In the early 1980's, a second introduction, a monoecious plant, was discovered in the Washington, D. C. area and this has since spread at least as far as North Carolina. (In dioecious plants, an individual plant has flowers of only one gender, while monoecious plants bear flowers of both genders.) Sutton and Van (1992) have recently reviewed the growth habits and productivity of the two U.S. biotypes of hydrilla. Efforts in this laboratory have been concerned with finding reliable molecular markers to distinguish the biotypes that are now established in this country and to detect new introductions. The presence of new biotypes is of concern for several reasons. The first is related to the mechanism of the introduction and the area of origin of the introduction. Another concern is the biological consequences of new introductions, such as decreased susceptibility to chemical or biological control. And yet another concern is the possibility of introduction of a biotype that is a vigorous producer of seeds (Steward 1993; Lal and Gopal 1993).

## Appearance

The two biotypes can be distinguished by features of their growth habit. In the same habitat, the dioecious plant produces longer and wider leaves and looks more

robust than the monoecious plant. These are characteristics that people familiar with hydrilla use, sometimes in an almost unconscious way, to do a preliminary assessment of the biotype at hand. Hydrilla biotypes can be distinguished by their canopies in the water column (Van 1989). Monoecious hydrilla, growing from sprouting turions in the soil, tends to spread on the bottom, then grows upwards, while the dioecious plant first grows to the top of the water column and then spreads laterally near the surface. While these characteristics, and others such as internode distance, may be useful to the experienced person in distinguishing the biotype, they are subjective to a great extent and all these features are plastic, i.e. they can change in response to the environment. Appearances can be deceiving. Small plants in an otherwise robust looking growth of the weed may indicate the presence of the monoecious biotype, or may be due to poor nutrition or other unfavorable growing conditions. The most useful markers would be constant.

## Isoenzymes and turion proteins

We presently screen new samples of hydrilla using non-denaturing electrophoresis of turion extracts. Subterranean turions, or tubers, are the tissue of choice because they are present in almost every infestation, and are apparently less subject to damage in handling, shipping and storage than stem and leaf tissue. Extracts of turions of known monoecious and dioecious biotype are run alongside test samples. Polyacrylamide gels are run at 4° C and staining is conducted for

protein, and for the enzymes aspartate aminotransferase and alcohol dehydrogenase. The patterns on the gels of the turion extracts distinguish the dioecious and monoecious plants presently in the U. S. There are some problems with this type of analysis. Variant patterns of enzyme activities, presumably due to ageing, have been seen in field-collected turions (Ryan 1989). These variants are not specific, since plants grown from turions displaying the variant patterns produced turions with the usual pattern of isoenzymes (Ryan, Thullen and Holmberg 1991). The second problem with analysis at the isoenzyme level is that a lot of genetic variation may be undetected. For instance, no differences were seen in the isoenzyme patterns for plants of the monoecious biotype from North Carolina and the Washington, D. C. area (Ryan 1989), although differences were noted in physiological parameters of these plants (Steward 1991) and these differences presumably are the results of genetic differences among the plants. The lack of resolution of biological variation could have serious consequences if a newly introduced biotype appeared by isoenzymic analysis to be similar to either of the presently established biotypes, but yet had some unexpected properties, such as the ability to set viable seed. There are 24 biotypes of hydrilla known worldwide (Verkleij and Pieterse 1991), although vast areas have been surveyed only superficially (e. g., China) and the area of greatest apparent diversity, Indonesia and associated islands, has not been studied in great detail. Other methods with greater resolving

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power than isoenzymes needed to be developed.

**RAPDs and genetic fingerprints**

The random amplified polymorphic DNA (RAPD) assay is proving useful in probing aspects of genetics of plants, fungi, insects, and higher animals. The RAPD reaction was first described by Williams et al. (1991) and approximately 100 papers have been published on this technique and its applications. The assay is a way of generating artificial genetic markers for an organism, using that organism's DNA and compounds called primers. These primers are composed of bases, the same units that make up DNA itself, but they are very much smaller than DNA; the primers are ten units, called bases, long, while DNA is on the order of a billion bases long, and double stranded as well. The primers recognize and bind to complementary sites on the DNA. The details of the reaction are beyond the scope of this paper but the products of the reaction are amplified copies of the plant DNA

located between primer binding sites. These are separated by electrophoresis on an agarose gel and stained with dye that fluoresces under ultraviolet light when bound to DNA. Each DNA will produce a pattern of bands, something like a bar code, in the presence of a primer. Each band is a genetic marker. DNA's are compared by noting the number of bands they have in common with a particular primer, and comparisons are made using several primers, to increase the number of markers being compared. The RAPD assay has a number of advantages over isoenzymes in assessing genetic similarities. Genomic DNA (that is, total DNA) is relatively easy to isolate, is independent of the condition of the plant with regard to age or stress conditions (within limits), and can be extracted from dried tissue, for example herbarium specimens, and only small amounts of DNA are needed for the assay. We use 15 nanograms of DNA per reaction and can isolate approximately 500 micrograms of DNA from 20

milligrams of dry tissue. (For reference, a nanogram is one-billionth of a gram while a microgram and a milligram are one-millionth and one-thousandth of a gram, respectively; there are approximately 27 grams per ounce. These are very small amounts). Primers are available commercially; each primer can potentially generate 1 to 10 bands and the primers probe all parts of the DNA. Variation can be detected at the level of the individual, among populations at a location, and among populations at different locations. It is difficult to compare a large number of markers using isoenzymes, particularly if the amount of tissue is limited.

The RAPD assay has, nevertheless, a number of disadvantages. It is fairly expensive to run, around \$1.00 per assay. When working with DNA that has not been previously characterized with this assay, it is necessary to screen a collection of primers to find, first of all, those that work and secondly to determine those which will detect

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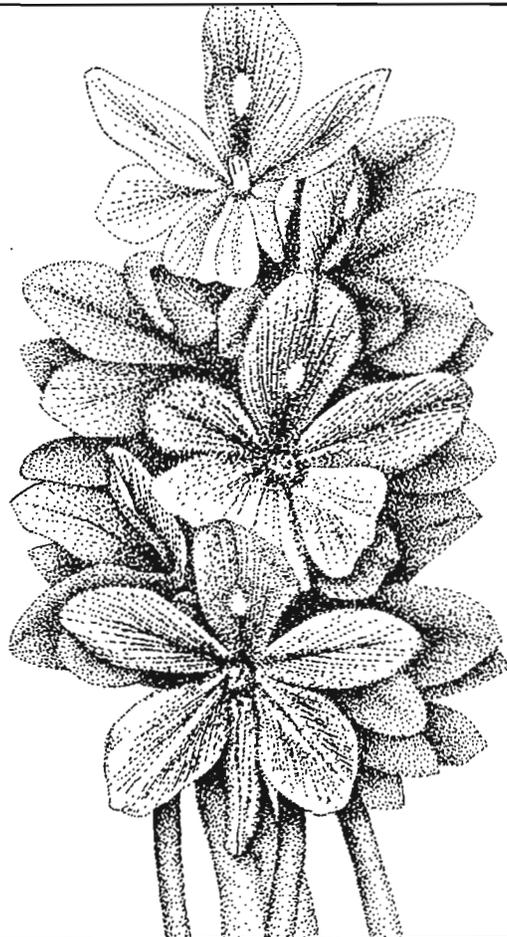
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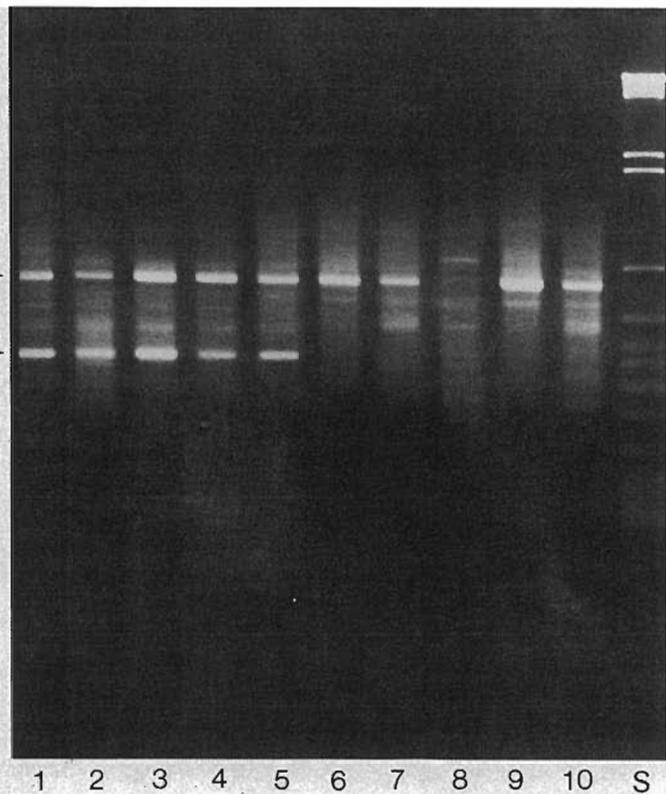


Fig. 1. Results of the RAPD reaction with DNA from monoecious or dioecious hydrilla and primer Operon G-17. From the left, the DNA sources are: 1) Lake Marion, FL (D); 2) Florida (USDA Aquatic Weed Lab, Ft. Lauderdale) (D); 3) Lake Gaston, NC (D); 4) Calexico water supply empondment (Imperial County, CA) (D); 5) Dahlia lateral (Imperial County, CA) (D); 6) pond in Delaware (M); 7) Dyke Marsh, VA (M); 8) pond in Maryland (M); 9) Tulare county, CA (M); 10) Lake Gaston, NC (M); and molecular weight standards. The arrows mark molecular weights of 485 and 850 base pairs.

variation at the level appropriate for the experiment. There can be substantial initial investment in the method, in terms of time and money, in determining which primers to use, but as more successful investigations are reported, effective primers may become apparent, that is primers that are particularly good for different species or families of plants.

DNA has been isolated from plants of both biotypes of hydrilla. For the dioecious plant, isolations have been done on individuals collected at

several sites in Florida and from 3 sites in the Imperial Valley, CA. Isolations have also been done on monoecious plants from the Potomac River, from areas within and around the District of Columbia, and from several sites in North Carolina. To date, 48 primers have been tested on these DNAs. Only 5 of the primers gave good amplification products: strong, distinct, and repeatable bands. one primer was particularly useful in distinguishing the monoecious and dioecious biotypes; DNA from most of the monoecious plants gave a single major product with a molecular weight of approximately 850 base pairs, while DNA from dioecious plants gave two product bands, of molecular weights 850 and 485 base pairs, respectively (Fig. 1). Work is underway to find other primers that give strong amplification and that provide polymorphic products for dioecious and monoecious hydrilla.

#### Applying the Strategy

In the spring of 1993, a new infestation of hydrilla was reported in Tulare county, California. The owner of a nursery noticed a nuisance

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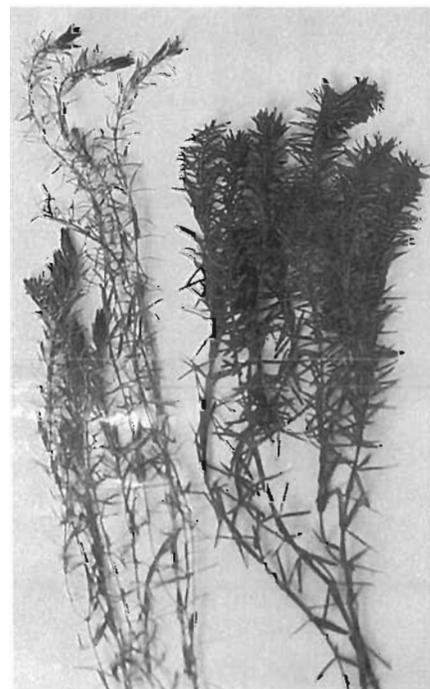


Fig. 2. Hydrilla from Tulare county, CA, on the left side of the picture. On the right side, dioecious plants originating in Imperial county, CA. Plants were grown in 1000 liter cultures outdoors on the same soil mixture and with a common water source.

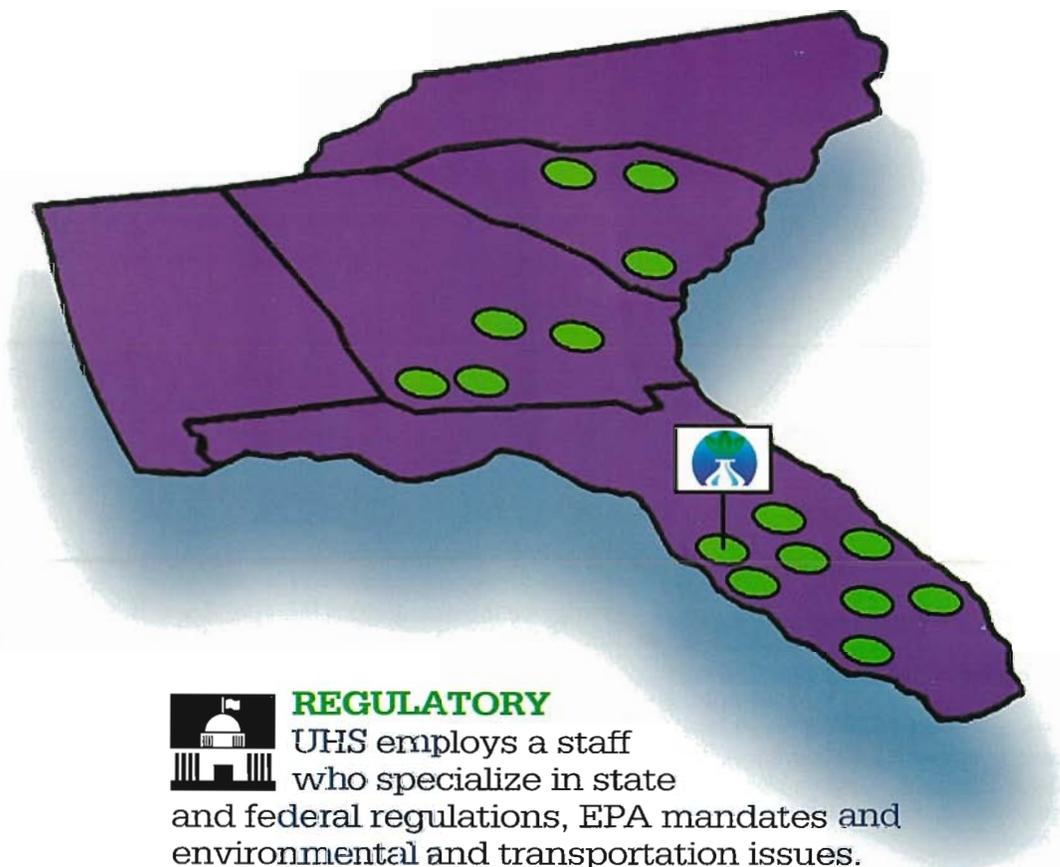
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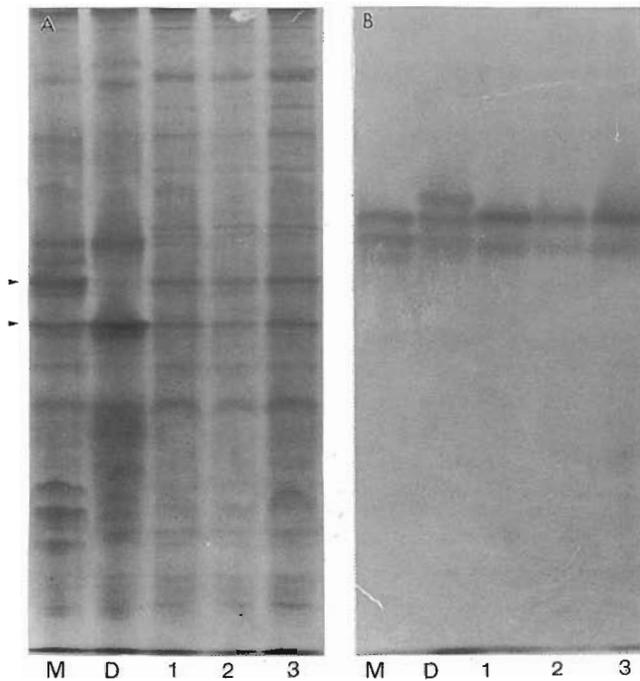


Fig. 3. Electrophoretograms of extracts of turions of known biotype and the plant from Tulare county. Gels were stained for (A) protein or (B) aspartate aminotransferase. M and D stand for extracts from turions of known monoecious and dioecious plants, respectively. Lanes 1 to 3 contain extracts from turions from the plant from Tulare county grown at the USDA Aquatic Weed Lab in Davis, CA. Diagnostic bands on the gel stained for protein are marked with arrows.

growth of an aquatic weed in ponds used for waterlily production. Biologists from the California Department of Food and Agriculture noted that the plant was not a typical dioecious hydrilla, the only biotype found in the state up to that point,

although they were certain that it was hydrilla because of the presence of turions in the soil. In Fig. 2 several stems of the plant from Tulare county are compared to those of a dioecious plant from Imperial county, CA. The plants in the picture were grown at the USDA Aquatic Weed Lab in Davis, CA and maintained in the same soil mixture, at equal temperature and light intensity for approximately 6 weeks at the time of this photo. The plants from Tulare County look much less robust than the

dioecious plants from the Imperial Valley, suggesting that the former may be the monoecious biotype.

When the infestation was found during the spring, only a small number of intact turions were present in the soil of the pond: most of the turions in the soil were husks of those that had sprouted earlier in the season. Non-denaturing gel electrophoresis of extracts of several intact turions had the patterns for protein and the enzyme aspartate aminotransferase that were similar to those from turions of the monoecious plant in culture at the USDA lab and were readily distinguished from those of the dioecious plant (Fig. 3).

The production by the plant in culture of both male and female flowers (Fig. 4) later in the summer confirmed that it was the monoecious biotype.

This infestation in Tulare County was discovered while we were developing the RAPDs assay and the monoecious character of the hydrilla was established by the production of male and female flowers prior to diagnosis by RAPDs. In a RAPDs reaction with the primer that was able to distinguish the monoecious and dioecious biotypes, the plant from the Tulare ponds produced the same reaction product as other monoecious plants from the eastern U. S. (Fig. 1). Typical reaction products are shown in Fig. 1; the amplified products from the plants from Tulare county are in lane 9, and are identical to those from monoecious plants from Delaware (lane 6), Virginia (lane 7) and North Carolina (lane 10). Products from dioecious plants from Florida (lanes 1 & 2), North Carolina (lane 3), and California (lanes 4 & 5) are different from those from the monoecious plants. A report is being prepared with Dr. Stratford Kay of North Carolina State University on the co-occurrence of the monoecious and dioecious plant in a single lake in that state (Ryan et al. 1994). Aberrant reaction products, such as in lane 8, are sometimes produced but these simply lack either of the diagnostic bands. Questions remain about the specificity of this analysis and work is underway to determine whether the present library of primers is able to distinguish the monoecious plant from different sites on the east coast. A more important question is whether the present set of primers can identify biotypes of hydrilla from other parts of the world. Regardless of its biotype, hydrilla in Tulare county is under an eradication program by the California Department of Food and Agriculture. The plant is being maintained at the USDA ARS Aquatic Weed Lab in Davis in the hopes that further information from the RAPDs reaction will allow us to determine its site of origin.

**Conclusions**

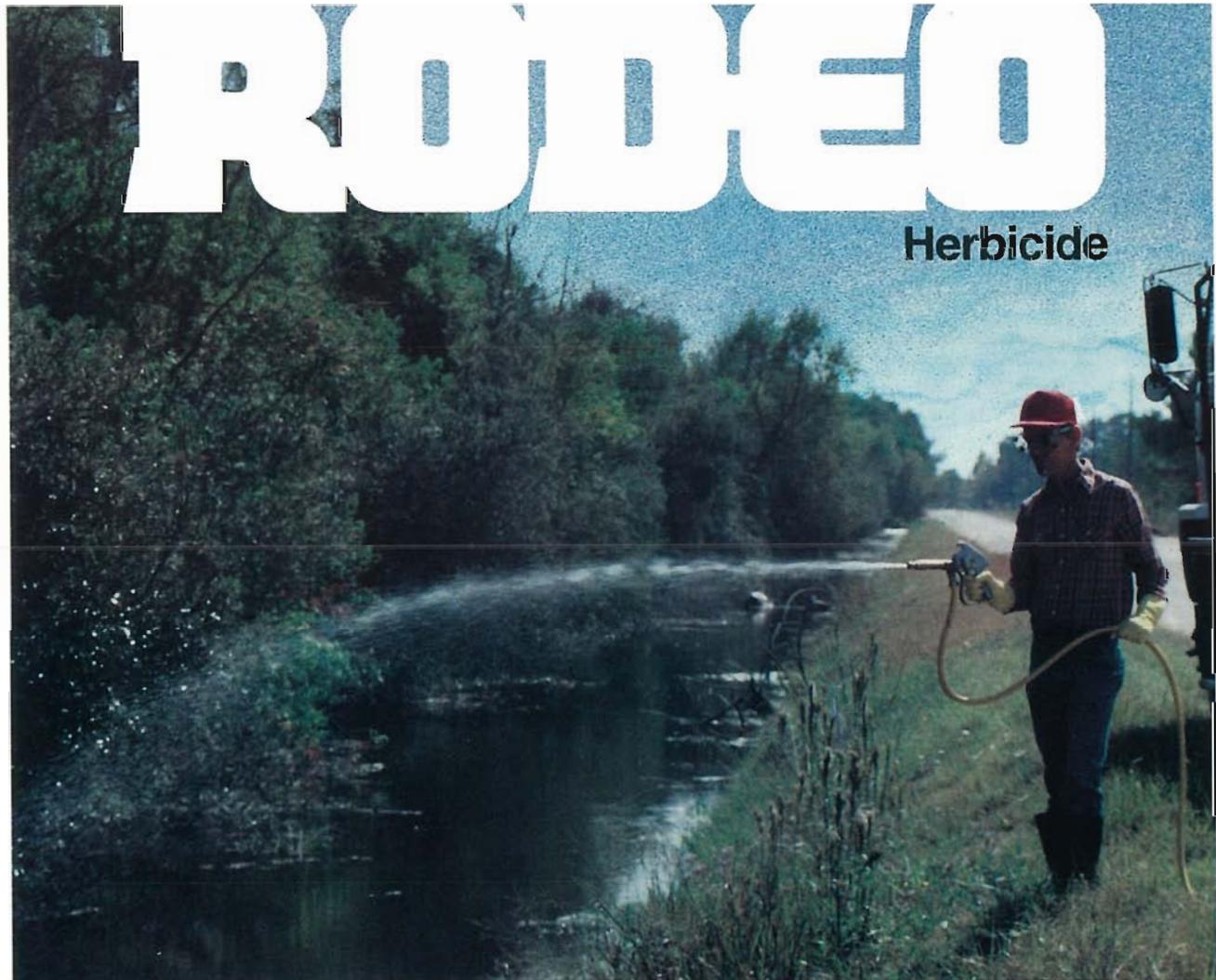
RAPDs analysis in combination with isoenzyme markers provides a means of distinguishing the two

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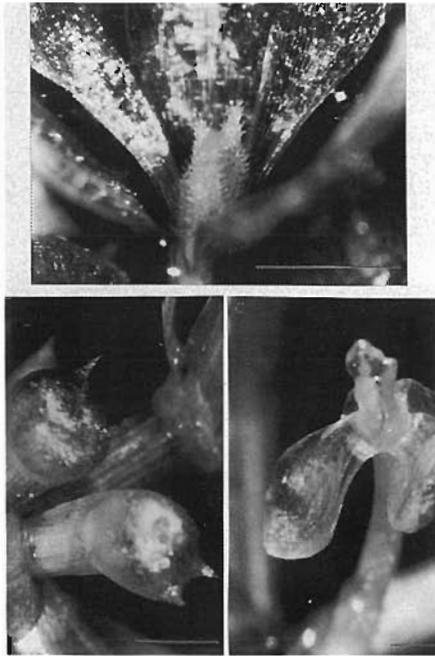


Fig. 4. Pistillate and staminate flowers of the plant from Tulare county. (A) The mature pistillate flower with a bundle of three stigmas at its center. The thumb-like projections on the stigmas are visible. (B) A pair of immature staminate flowers still attached to the stem. (C) A more mature staminate flower. The petals have recurved to expose the anthers. Bars equal 2.0 mm.

biotypes of hydrilla presently in the U.S. RAPDs analysis can provide information on the genetic structure of hydrilla., which supplements that already known from the studies with isoenzymes. It may allow the detection of sub-populations that carry large amounts of variation and which are thus candidate populations for seed production.

**Acknowledgements**

Dr. Kerry Steward, USDA ARS, Ft. Lauderdale, FL, has provided us with many samples including monoecious hydrilla from the northeastern U.S. Dr. Gary Buckingham, USDA ARS, Gainesville and Dr. Stratford Kay, North Carolina State University, provided us with field samples from Florida and North Carolina, respectively. Mike Mizumoto collected the plant in Imperial County, CA. Finally, thanks are due to personnel of the California Department of Food and Agriculture, who provided us with samples of the infestation in Tulare County, before treating it.

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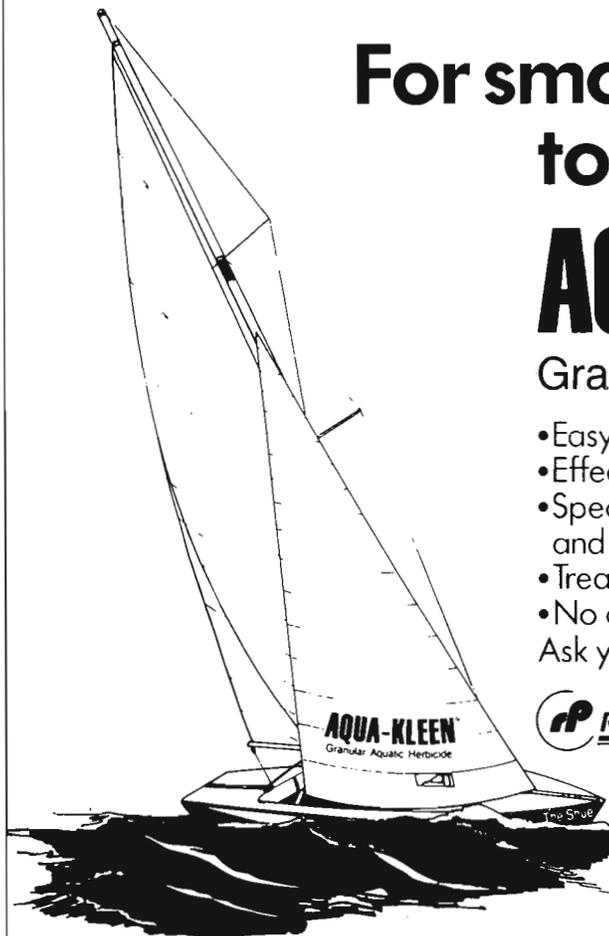
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# AQUAVINE



## MEETINGS

### Recognition

Dr. Donn Shilling, IFAS Agronomy Department and Center for Aquatic Plants was recognized as the IFAS Graduate Teacher/Advisor of the year. Donn was also promoted from Associate Professor to Professor.

### The "Big Quiet Guy from Hillsborough County" is Retire'n

The "Big Quiet Guy" from Hillsborough County, who never misses an FAPMS or APMS meeting, is James "Dan" Gorman. Dan will retire June 10, 1994 after thirty eight years of public service to the County. He has served as Director of Mos-

quito and Aquatic Weed Control since 1956 and has also directed the county landfills and Animal Services.

Dan is a Charter Member of the Hyacinth Control Society (now APMS) and served as President in 1966-67. He also served as President of the Florida Anti-Mosquito Control Association in 1973-74 and was American Mosquito Control Association, South Atlantic Region Director in 1974-78 and 1980-82.

In his retirement, Dan will be waiting for a new Grandchild to be born and do alot of traveling (and I bet he'll be looking for hydrilla and hyacinths everywhere he goes). Have fun Dan - we'll see you at the meetings.

### Environmental Horticulture Program at Fort Lauderdale

A Bachelor of Science in Environmental Horticulture is available at the University of Florida's Fort Lauderdale Research and Education Center. This program in horticulture provides the opportunity for students to earn a B.S. degree from the University of

Florida without relocating to the Gainesville campus. The program is cooperative, making use of courses available at Florida International University, Florida Atlantic University, and area Community Colleges. The horticulture courses offered at the Fort Lauderdale Center are part of the University of Florida curriculum and have the same content as those offered at Gainesville.

All classes offered at the Fort Lauderdale Research and Education Center are conveniently scheduled in the evening or Saturday and meet once a week during the 16 week semester. People interested in professional advancement, but not seeking a degree, may take courses either for credit (for a grade) or audit (which means the same material will be provided, but the student will not be required to take exams and will not receive a grade or credit toward a degree).

The 1994 Fall semester begins on August 22. This fall, Dr. David Sutton will offer Identification and Ecology of Aquatic Plants (ORH 4932, 3 credits). Other courses being

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Tampa, FL 813/626-5121 Tom McPherson*	Palmemo, FL 813/722-3253 Dale Willis Keith Foster
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	Delray Beach, FL +07/499-0486 William Horrie F.E. "Chil" Rossbach*

\*Aquatic & Industrial Specialist

offered for the 1994 Fall semester include: Genetics, Orchidology, Horticultural Production Manager Seminar, Tropical Horticultural Entomology, General Horticulture, Principals of Horticulture Compost Technology, Production of Floriculture Crops and Independent Study of Environmental Horticulture.

For more information on course requirements, costs, or scheduling, please contact the University of Florida, Fort Lauderdale Research and Education Center, 3205 College Avenue, Fort Lauderdale, Florida, 33314: (305) 475-8990.

### APMS 1994 Annual Meeting

The Aquatic Plant Management Society will hold its 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).

### European Weed Research Society 9th International Symposium on Aquatic Weeds

The European Weed Research Society are organizing an International Symposium on Aquatic Weeds, which will be held in Trinity College, Dublin, Ireland during September 12-16, 1994. This is the 9th in a series of symposia aimed at discussing international weed problems, approaches to aquatic weed control and factors affecting the growth, ecology, and performance of aquatic plants. For information contact Dr. Joe Caffrey, Central Fisheries Board, Mobhi Boreen, Mobhi Road, Glasnevin, Dublin 9, IRELAND. Tel: 353-1-379206, FAX: 353-1-360060.

### MISCELLANY

#### New Telephone Numbers at the CAP

The IFAS Center for Aquatic Plants is gradually catching up with the 20th

century. We have installed one of those high tech phone systems. You will have direct access to faculty and staff, who now have direct phone numbers. When we are not in, your call will automatically forward to the clerical staff. If clerical staff is unavailable, you can leave a message on voice mail. The following is a list of new numbers:

Main number: (904) 392-9613

Information Office:

392-1799 & 392-6843

Glenn, Margaret: 392-6892

Goodwin, Bobbi: 392-6807

Haller, Bill 392-9615

Joyce, Joe (Vacant) 392-6841

Langeland, Ken 392-9614

Smith, Brian 392-6894

### The Great Shift

Tori Kinsey has moved south to Okeechobee into a new biologist position with the U.S. Army Corps of Engineers. Tori will be covering APC Cooperative Program Operations in Highlands and Polk Counties, the southern portion of Southwest Florida Water Management District, the Kissimmee River, and the Kissimmee Chain of Lakes. Her new office number is 813/763-2128.

Katherine Robbins has left the cubical maze of the U.S. Army Corps of Engineer's District Office to become the field biologist in the North Florida Operations Office in Palatka. Katherine will monitor aquatic plant control operations in Brevard, Lake, and Orange Counties and SJRWMD operations.

### IN MEMORIAM

**Rodger Rottmann**  
1950-1994

Rodger Rottmann died April 3, 1994. Those of us who knew Rodger will remember him, not only for his accomplishments in fisheries science, but for the example he set in accepting his long term fatal illness.

Rodger conducted and published extensive research in areas ranging from white bass production to ornamental fish production. Those of us in aquatic plant management will remember him best for his pioneering work in all aspects of grass carp production, use, and ecological affects, on which he published over

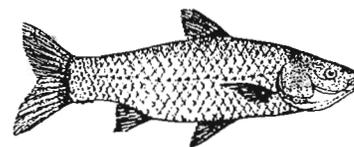
20 scientific and technical papers. His latest accomplishment was the videotape, "Hormone Induced Spawning of Grass Carp."

**Robert P. Blakeley**  
1917-1994

On March 30, 1994 we lost a long time friend and a booster of many good works, including the Florida Aquatic Plant Management Society.

Bob was appointed to the Board of Governors of the Central and South Florida Flood Control District by then Governor Kirk, and served a year as its chairman. He served as a supervisor of Old Plantation Water Control District for forty years, most of the time as chairman. He was a Board member of the Hyacinth Control Society; he was a charter member of our Society, and founding member of the Florida Association of Special Districts. The list of benevolent and community groups who used Bob's skills could be multiplied, but most of us will miss him because he was an honorable man who saw the good in his fellow citizens.

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