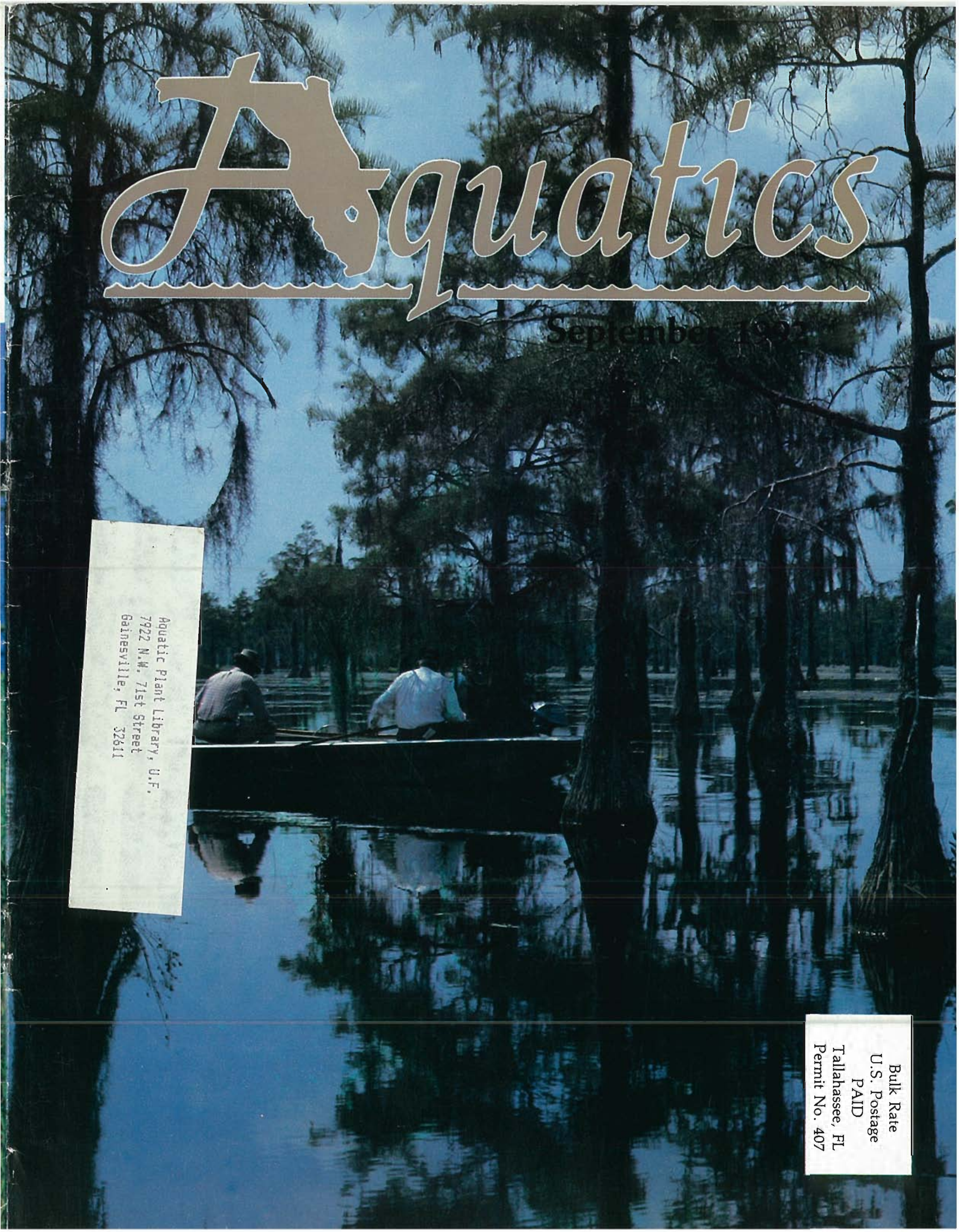
Aquatics

September 1992



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Editorial

Time Travelling Through Mucky Waters

Rewind to the 1950s and subtropical Florida. Water hyacinths trouble many lakes and rivers, but thousands of water bodies still harbor healthy wildlife and provide tremendous recreational opportunities. Boaters glide through sparkling, open waters while otters, egrets, and Everglades kites easily probe for their dinners.

Fast forward to the 1990s and another Florida waterway. As a boater clears the intake of his overheating engine, an Everglades kite tries, in vain, to find snails in the green mass filling the lake from top to bottom. What happened here?

Obviously, during these 40 years hydrilla snuck in, and there went the neighborhood. Invading hydrilla populations didn't know their place, trashed up the whole area, and, well, "you just can't trust 'em." Thankfully, measures have been found that can handle the problem. Herbicides and/or grass carp can control large hydrilla stands, but at a price.

While Florida benefits from one of the world's longest-running aquatic plant management programs, hydrilla's rampage can only be repulsed with consistent, and perhaps ever-increasing, funding. Every year, hydrilla sneaks into more waterways, so costs keep mounting.

The 1992 Florida Legislature increased aquatic plant control money by $2.5 million, bringing 1993's pot of federal and state money to $10.4 million. But at least $14.3 million are needed to pay for all the aquatic progrms administered by the Department of Natural Resources.

Add to that DNR's legislative mandate to fund $1 million worth of melaleuca management in 1994. Where will funds be found? Will state legislators entertain this subject again, during what will undoubtedly be another year of fiscal crisis? We cannot ease up on our lobbying, cajoling, and...begging. Our profession's efforts must continue to be effective and well-coordinated. We have just begun to fight, **again!**

Mike Bodle

About The Cover

Fall's coming to the backwoods and the big ones are biting on Guest Mill Pond, Georgia.

Photo by David P. Tarver.

Aquatics

September 1992/Vol. 14, No. 3

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EDITORIAL: Address all correspondence regarding editorial matter to Mike Bodle, Editor, *Aquatics* Magazine, P.O. Box 24680, West Palm Beach, FL 33416.

Carrotwood: An Invasive Plant New to Florida

by J. Douglas Oliver
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Introducation

Cupaniopsis anacardioides (A. Rich.) Radlkf. (Sapindaceae), commonly known as carrotwood or the tuckeroo tree, is a native of Australia that was brought into Florida in about 1980. Biologists, environmentalists, and others have demonstrated concern about this plant: "Seedlings are beginning to sprout in Martin County [in South Florida] in an alarming variety of habitats. At least one seedling has been found growing behind mangroves along the Intracoastal Waterway... It appears that the seed... remained viable for some length of time in saltwater," (M. Hurchalla, Martin County Commissioner, 1990). This report is a review of the scientific literature.

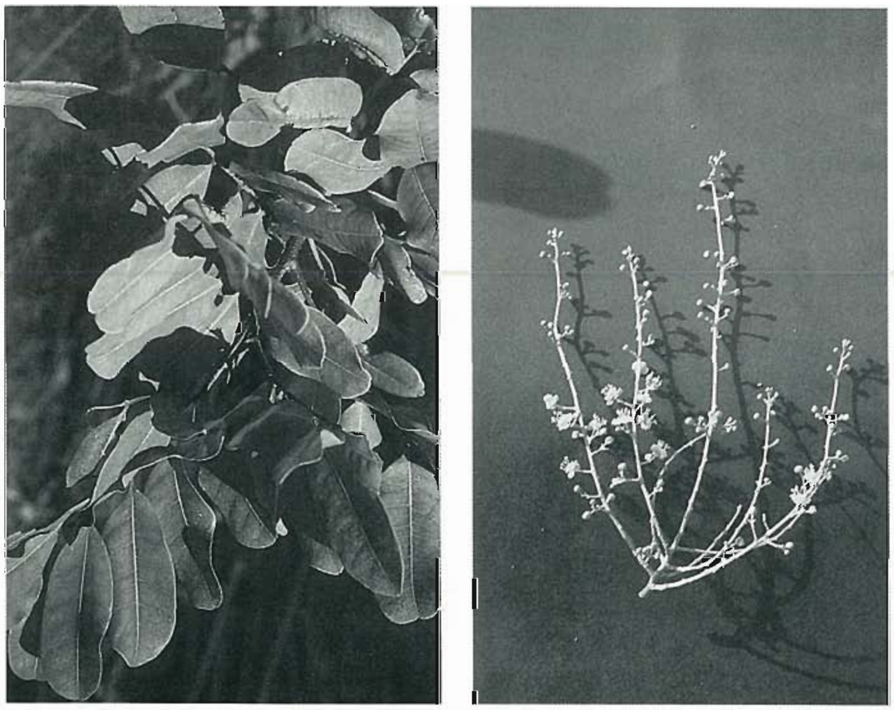

Figure 1. Leaves and flowering parts of adult Cupaniopsis anacardioides. *Photographs by Technical Services Section, Bureau of Aquatic Plant Management.*

Little scientific information is available for *Cupaniopsis anacardioides*, alternately known as *Cupania anacardioides* (Mustafa et al., 1986). For example, a search of *Biological Abstracts* from January 1987 - June 1991 listed only one paper published on this species. (In that paper, Hawkeswood [1988] listed several food plants of an Australian butterfly, including *Cupaniopsis anacardioides*).

Distribution

C. anacardioides has been introduced in various subtropical parts of the world as an ornamental plant (including California, Stresau, 1986) and was probably brought into Florida as a landscaping plant. In Florida, *Cupaniopsis anacardioides* has increased from a virtual absence to a growing abundance, in a short period of time.

Cupaniopsis anacardioides has been spreading in Florida. During the early 1980s, its first years in the state, *C. anacardioides* was apparently limited to ornamental cultivation. In the late 1980s, seed production was observed and resulted in dispersion into natural areas. It has been found on spoil islands of the Intracoastal Waterway in the Indian River lagoon, and in Martin County. A 1988 survey of the vegetation of over 100 spoil islands revealed no *C. anacardioides*, but frequent occurrence of the young plants of this species was found in a 1990 inspection (J. Jordan, pers. comm., 1990). Thus, this exotic plant has become established and is starting to replace native vegetation along the southeast Florida coast. In 1991, it was also found in Oscar Scherer State Recreation Area, Sarasota County (Anonymous, 1991).

Discription and Identification

C. anacardioides is a medium sized tree, up to about 30 x 30 feet in size (9 x 9 m, Stresau, 1986). It is slender and mostly glabrous and has a single trunk (Hawkeswood, 1983a). The color of wood inside the bark is frequently orange, from which this species derives the common name of carrotwood.

The plant has compound leaves with 6 to 10 leathery leaflets, each about 4 inches long (10 cm, Stresau, 1986; Fig. 1). The flower is an axillary raceme 10 inches (25 cm) long, containing many small lime-green flowers, each about 3/8 inch (1 cm) in diameter. The branched raceme holds numerous globular ridged fruits, each 1/2 inch (1.3 cm) in diameter; each

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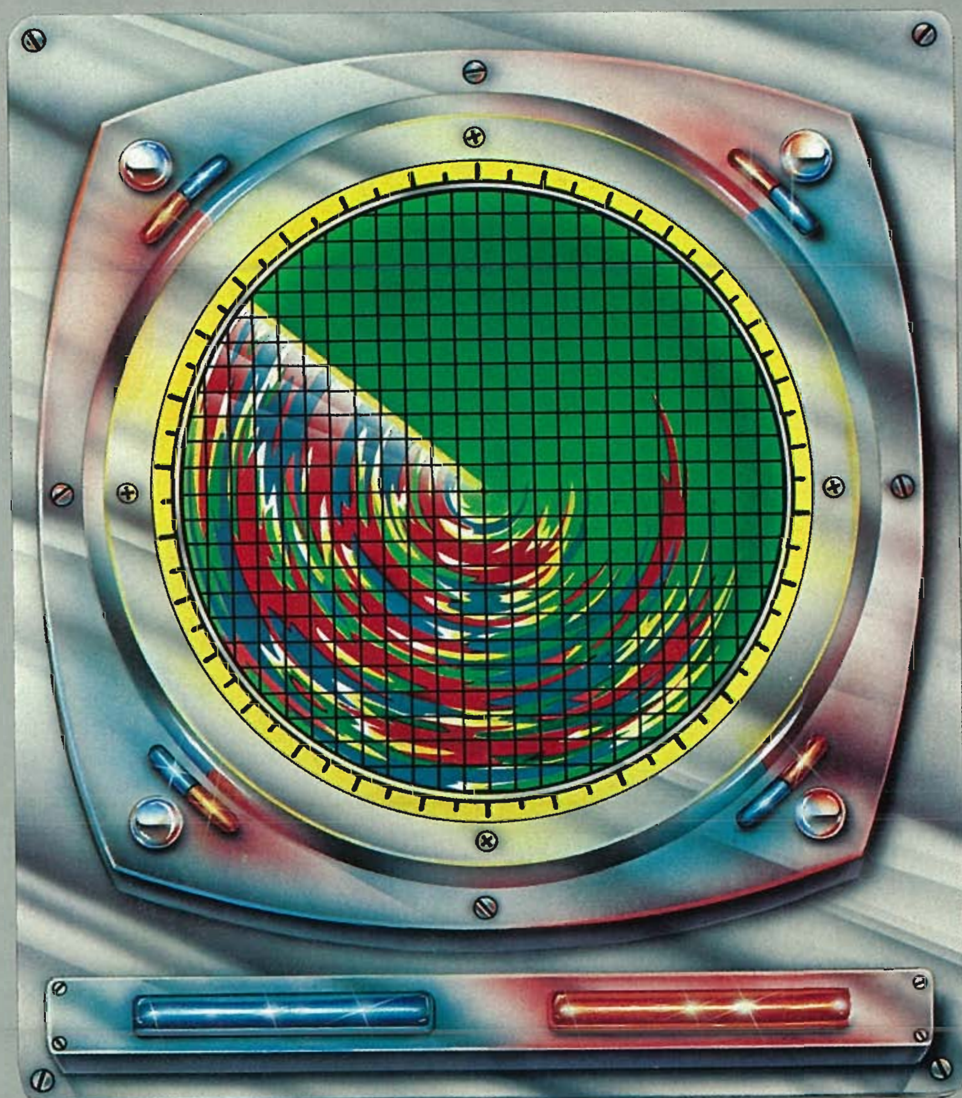
Weeds or desirable plants?



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fruit is dilocular or trilocular, with one ovule per loculus. The seeds possess a fleshy aril and a crustaceous testa (Hawkeswood, 1983b).

Biology

Cupaniopsis anacardioides can produce a large number of fruits and seeds per tree (Hawkeswood, 1983b), contributing to the invasiveness of the species. In eastern coastal Australia, pollination is mainly by small Australian bees (*Trigona carbonaria*, Hawkeswood 1983a). If birds are found to carry the seeds, they would accelerate invasiveness to an even greater degree (B. Dehgan, Envir. Hort. Dept., Univ. Florida, 1991).

In its native Australia, the plant grows in coastal rainforest and vine thickets in southern Queensland and northern New South Wales (Hawkeswood, 1988). This area is relatively wet and subtropical, so it is climatologically similar to much of Florida. Thus it is not surprising that *C. anacardioides* can invade wild wet areas in Florida.

The presence of the plant on coastal spoil islands suggests that seeds and/or vegetative structures are tolerant of some salinity. A gardening book reports that *Cupaniopsis* is generally salt tolerant (Stresau, 1986). This species flourishes on the sandy coastal strips of the east coast of Australia where its roots reach a considerable distance to the water table (Oakman, 1964, not seen; Hawkeswood, 1983a). In that environment, it can withstand heavy salt sprays.

Oliver and Jubinsky (in prep.) performed experiments to provide a screening of the potential of young plants of *C. anacardioides* for invading various types of Florida aquatic habitats. They found that a high percentage of plants would survive when raised in soil wetted with brackish water (artificial 1/2-seawater), but not when continually inundated with brackish water. Thus the plant could invade tidal estuarine and coastal wetlands, as well as freshwater lakes, rivers, and wetlands of Florida.

The plant tolerates poor soil and poor drainage, but also adapts to dry areas (Stresau, 1986). Even young plants can survive freshwater inundation (Oliver and Jubinsky, in prep.).

The year-round growth of *C. anacardioides* in southeast Florida suggests that the plant may be tolerant of cool winter temperatures. Stresau (1986) notes that older plants are cold tolerant to about 22°F (-6°C). A nurseryman on the southwest coast of Florida stated that only about twenty-five percent of his *C. anacardioides* stock died during the December 1989 cold period, when air temperatures went below freezing for several days (Jordan, 1990).

In experiments in North Florida, young plants were not killed by Tallahassee winter temperatures that went as low as -4°C overnight (Oliver and Jubinsky, in prep.) Thus *C. anacardioides* appears to pose a threat to environments of the North Florida climatic zone.

In the same series of experiments, shading did not have consistent nor obvious effects on *C. anacardioides*. Apparently the plant can survive well in areas with significant cover, and is able to invade areas that have some overstory.

The plant is occurring in increasing frequency in South Florida habitats. Because *C. anacardioides* is relatively new in the state and not concentrated in any one location, biologists are generally not willing to make estimates of densities, at least not yet. However, there are at least two estimates of the spacing of plants, given below.

From 1987-1989, biologists G.W. Burzycki and R. Moyroud did a biological inventory of two islands in Indian River County and found no *C. anacardioides*; however, by 1990, young plants were observed coming up from seeds, every few meters. They had apparently been transported by birds (Burzycki, pers. comm., 1990).

Seedlings are reported to be emerging beneath Australian pine forests (*Casuarina* sp.) on Southeast Florida spoil islands. As many as 10 seedlings per square meter have been reported from this habitat (Jordan, pers. comm., 1992).

Importance

Cupaniopsis anacardioides is generally considered to be a handsome ornamental tree, which is "clean for poolside use" (Stresau, 1986). It gives heavy dense shade and has been popular for some time in California. In South Florida, the plant is widely marketed and planted, and is becoming a major nursery production item.

Management Options

Herbicides: A number of woody plant species can be controlled by herbicides. Herbicides such as GARLON and BANVEL 720 (dicamba plus 2,4-D) should be effective for removing *C. anacardioides* in upland areas (P. Myers, pers. comm., 1991), but in Florida they are not approved for use in sites with standing water (Fla. Dept. Ag. Consum. Serv., pers. comm.). RODEO and ACCORD (glyphosate) herbicides should be useful for aquatic sites, based on experience with other woody species.

Mechanical: Because so little has been published about *C. anacardioides*, it is not known whether mechanical control of the species would be effective or not. However, the normal production of large numbers of seeds might make such control quite difficult.

Habitat Manipulation: *C. anacardioides* can grow in wet or dry areas, so it would be difficult or impossible to control by water-level manipulation. Perhaps it could be burned when habitats are dry. Because the species can grow in relatively open or shaded habitats, it might be difficult to control by the artificial planting of competitors.

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

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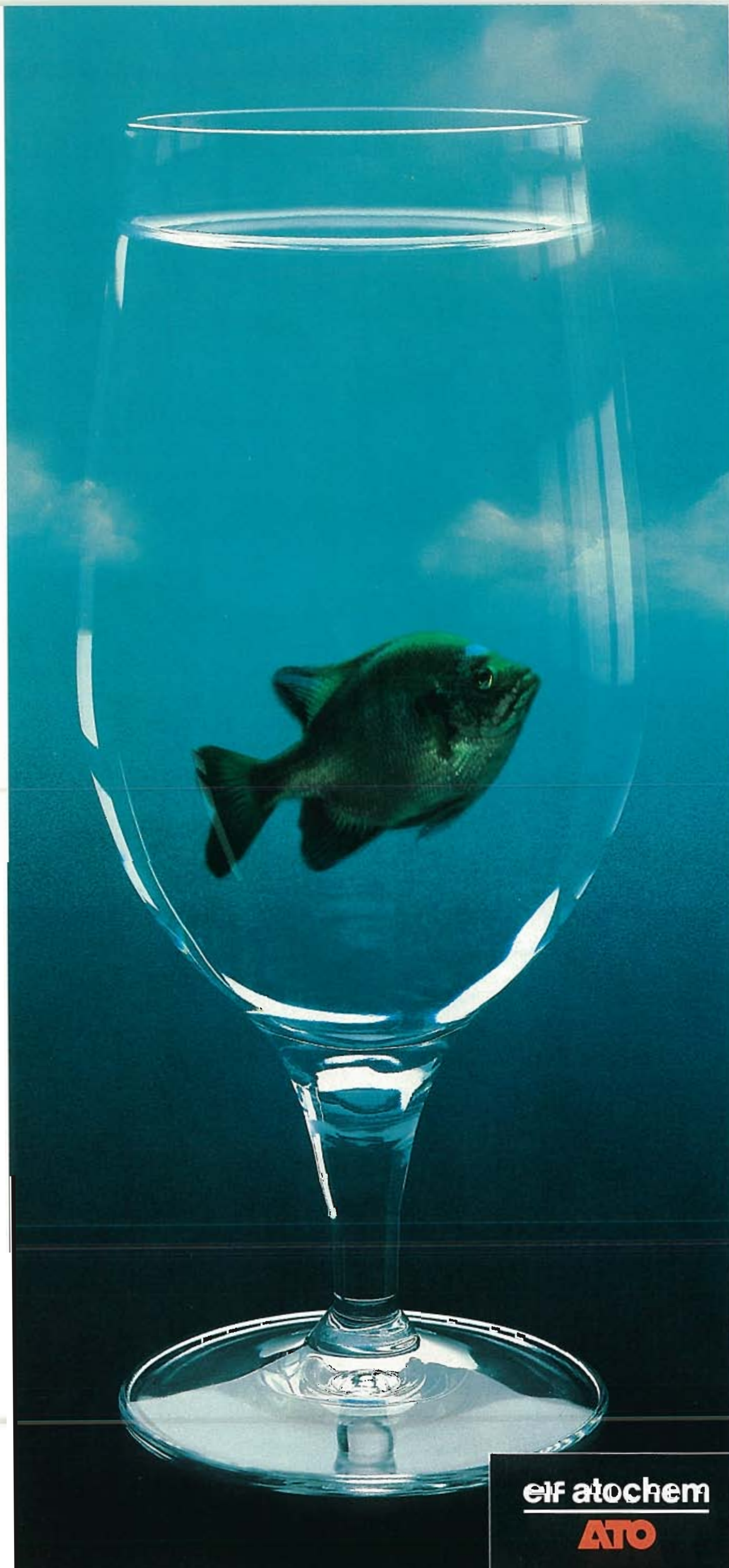

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Biological Control: Little is known about *C. anacardioides* or possible biocontrol of the species, but at least one Lepidopteran is reported to eat it. Hawkeswood (1988) reports larvae of the Australian butterfly *Prosotas felderi* (Lycaenidae) eating the plant. He observed a last instar larva feeding on the flowers. However *P. felderi* also feeds on several acacias (*Acacia floribunda, A. granitica, A. penninervis* var. *longiracemosa, A. podalyriifolia, A. sophorae,* and *A. leiocalyx* subsp. *leiocalyx*), as well as *Alectryon coriaceus, Macadamia integrifolia,* and the litchi nut tree *Litchi chinensis*. Thus this insect may not be appropriate for use as a biocontrol of *Cupaniopsis anacardioides* in the U.S.

C. anacardioides is parasitized by Homopteran scale insects. The lesser snow scale, *Pinnaspis strachani* (Cooley) was observed "lightly infesting" one hundred percent of 300 plants examined at a nursery near Pahokee, Palm Beach County (Mead, 1991). This parasitic insect was feeding through the bark, but the plants did not seem to be damaged. The Indian wax scale, *Ceroplastes ceriferus*, and the barnacle scale, *C. cirripediformis*, are also reported to attack the plant (A. Hammond, pers. comm., 1992). However, these species are not useful for biocontrol because they feed on a number of other hosts. It is likely that undescribed carrotwood-dependent insects could be discovered if *C. anacardioides* was investigated intensively in Australia (G. Buckingham, pers. comm., 1992).

Summary

The exotic plant *Cupaniopsis anacardioides* has been spreading through various wild fresh and saline habitats in South Florida. It is a handsome-looking ornamental plant that produces numerous seeds. Abundant reproduction and tolerance for shade, sunlight, dry, wet, and brackish-soil conditions result in a significant rate of natural colonization.

Experiments suggest that *C. anacardioides* would tolerate North Florida winter temperatures. Based upon a mean January temperature of 12° C in Tallahassee (1900-1990, NOAA, 1991), the plant is expected to extend its range northward through peninsular Florida and into the Panhandle, unless it is actively controlled.

It is not known whether herbicides, mechanical methods, or habitat manipulation can control the plant. No appropriate biocontrols are known, at least not yet.

The plant poses a threat to natural systems where tolerance to inundation and cover could allow it to replace native plants, and the natural ecological balance might be seriously altered. In terms of fish and wildlife economics, *Cupaniopsis anacardioides* competes with other plants that provide good habitat and food for these organisms. Thus the plant could have a negative economic impact on money-

generating hunting and fishing. This in turn could have a negative economic impact on tourism.

Regional biologists, park managers and other interested individuals should consider taking action to limit further spread. In Florida, observations of wild occurrences may be reported to the Bureau of Aquatic Plant Management, at (904) 487-2600.

Acknowledgments

Greg Jubinsky and Robert L. Kipker of the Bureau of Aquatic Plant Management encouraged this review. The State Library of Florida provided a computer search of the literature and copies of scientific papers.

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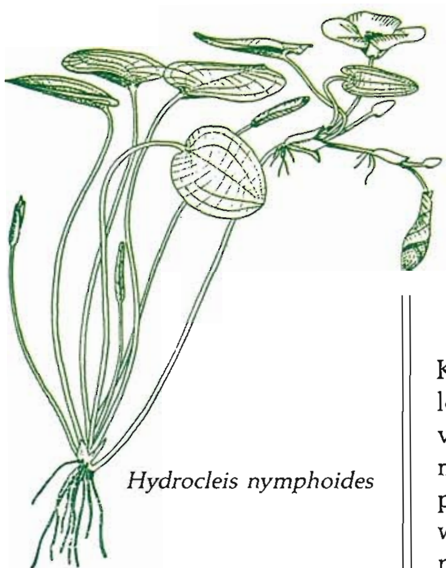
Characteristics of Flowering Aquatic Plants



Hydrocleis nymphoides

by
David L. Sutton
Fort Lauderdale Research and Education Center
University of Florida - IFAS
Fort Lauderdale, FL

Nymphaea tuberosa

Sagittaria latifolia

Hydrocotyle unbellata

Introduction

Plants are living beings of the Kingdom Plantae typically lacking locomotive movement and any obvious sensory organs, generally making their own food by photosynthesis, and possessing cell walls composed of cellulose. Plants may be divided into terrestrial, aquatic, marine, parasitic, and epiphytic groups based on anatomical features and growth habits. Although all plants share common characteristics, diverse groups may possess similar anatomical features and physiological characteristics that allow them to colonize, grow, and complete their life cycle in a particular habitat.

A major problem for plants living in and around water is exchange of gases. Without the ability to transport carbon dioxide to chloroplasts, maintain adequate oxygen supplies within the plant itself, or transport oxygen to various plant tissue, plants could not live for long in the anoxic conditions common in aquatic ecosystems. Aquatic plants accomplish this with specialized tissue to help transport these gases.

Plants colonizing and completing their life cycle in watery environments share morphological and physiological characteristics that allow them to survive and grow under these conditions. Aquatic plants include representatives of algae, fungi, mosses, ferns, and flowering plants.

Even though flowering aquatic plants live in and around water, most of them lift their flowers above the surface of the water in order for insects and wind to assist in pollination in the same manner as terrestrial, flowering plants. Only a few aquatic genera such as *Althenia, Ceratophyllum, Najas, Ruppia, Zannichellia*, and several species of *Callitriche* rely solely on hydrophily (water pollination) for pollination of their flowers.

In addition to the production of seeds, flowering aquatic plants produce a variety of vegetative propagules such as tubers, turions, corms, root tubers, and rhizomes that allow them to survive adverse periods when an aquatic habitat dries out or to over-winter. Hydrilla (*Hydrilla verticillata* (L.f.) Royle) is a good example of a submersed plant that produces axillary turions in the shoots and subterranean turions, commonly called 'tubers', at the ends of rhizomes in the sediments that help ensure its survival. Other aquatic plants, such as watermilfoil (*Myriophyllum* spp.), when subjected to adverse growing conditions, produce emersed land forms which are very small, reduced shoots completely different in shape and size as compared to the normal submersed growth habit for these plants.

Definitions of Aquatic Plants

Aquatic habitats are not as clearly delineated as terrestrial ones. There is no abrupt change from dry land to water. Some areas may alternate between flooding and a dry state on an annual basis. Other areas may contain standing water

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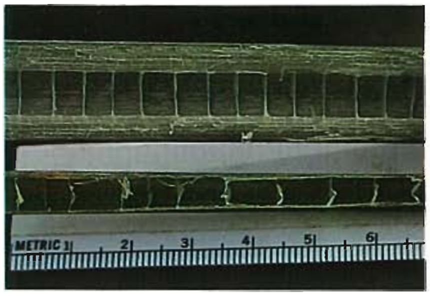


*Figure 1: Longitudinal stem sections of pickerelweed (*Pontederial cordata *L.) top, and spikerush (*Eleocharis interstincta*(Vahl) R. & S.), bottom showing the large air chambers present in the entire length of the stem.*

for long periods of time and then dry out. Water level depends on factors such as rainfall, watershed area, soil type, percolation, and drainage outlets. These factors in combination with temperature and solar radiation will influence the habitat available for growth of aquatic plants.

Some terrestrial plants tolerate flooding for short periods of time and some develop adventitious tissue (the presence of tissue

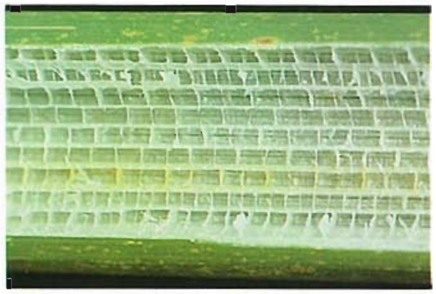


*Figure 2: Longitudinal section of cattail (*Typha sp.*) leaf showing the arrangement of rectangular air spaces located just beneath the epidermis and extending throughout the entire length of the leaf.*

such as roots growing on a plant where they generally are not normally present) in order to survive wet conditions for a period of time. However, these plants will eventually be unable to complete their life cycle if the wet conditions persist. It is not uncommon, for example, to see terrestrial plants growing in the Everglades of South Florida in late winter and early spring when the lack of winter rains results in severe drying of the muck soils present. Even after the rainy summer season begins and the water level has risen, these plants continue to survive. As the summer wears on and the flooded conditions continue, they eventually succumb to the wet, anaerobic conditions because they do not possess the unique charactristics that allow them to live under these conditions.

Aquatic plants may be defined as those plants that must live in or around water in order to grow and complete their life cycle. The common term "aquatic macrophytes" literally means large aquatic plants but has no real taxonomic significance. Hydrophytes, from the Greek "hydor" for water and "phyton" for plant, is an appropriate term to describe plants that live in water but not specifically referring to any particular species.

"Aquatic vascular plants" is an appropriate term for those aquatic plants containing conductive vascular tissue (phloem and xylem). Many aquatic vascular plants are flowering, produce seed, and may be referred to as "flowering aquatic plants."

Morphological and Physiological Characteristics

Unique morphological and anatomical characteristics of flowering aquatic plants that allow them to live, grow, and complete their life cycle in and around water include (1) aerenchyma tissue, (2) thin or no cuticle, (3) vascular bundles, (4) reduced number or lack of stomates on leaf surfaces, and (5) lack of tissue for mechanical support. Depending on the group to which a particular plant may be assigned (Table 1), these characteristics may be fairly obvious or difficult to differentiate. Also, some plants grow in such a manner that they can be included in more than one group. Heterophylly, the presence on a single individual of two or more distinct leaf shapes, is common for flowering aquatic plants such as mermaid weed (*Proserpinaca* spp.) and some of the arrowheads (*Sagittaria* spp.).

Aerenchyma Tissue

Flowering aquatic plants normally have a portion of their leaves or shoots exposed to an environment that allows for uptake of carbon dioxide and production of oxygen. The lower stem, root, and rhizome portions of aquatic plants generally grow under anoxic conditions, and must obtain oxygen from the photosynthetic regions of the plant. Aquatic plants display an abundance of air spaces that meet the need for movement of oxygen from the upper green portions of the plant to the lower sections with tissue in need of this essential element.

Plants contain various tissue types of which parenchyma is composed of living cells variable in their morphology and physiology, generally with thin walls, and a polyhedral shape. In aquatic plants this specialized parenchyma tissue, termed aerenchyma, functions both in cell aeration and plant buoyancy. Spongy tissue on the underside of young leaves of frog's-bit (*Limnobium spongia* (Bosc.) Steud.) is a good example of aerenchyma tissue.

Aerenchyma tissue with its large, abundant intercellular spaces, forms an elaborate, continuous system from the upper portion of shoots to the lower sections of the shoots, roots, and rhizomes of aquatic plants (Figures 1 and 2). The interconnecting air spaces in aerenchyma tissue allows for movement of oxygen from photosynthetic regions of the plant to cells that are oxygen deficient.

Cuticle

Surfaces of leaves of terrestrial plants are covered with cuticle to help prevent water loss, entry of diseases, and attack by herbivorous organisms. The cuticle is a continuous layer of fatty substances that varies in thickness, and its surface may be smooth, or with ridges, cracks, and protrusions.

Any portions of an aquatic plant growing above the surface of the water must be protected in a manner similar to terrestrial plants. Surfaces of emergent, floating-leaved, and surface free-floating plants are covered with cuticle.

Submersed plants do not have a problem with water loss. Submersed plants possess very thin leaves with little or no cuticle which allows for diffusion of gases from the water directly into the plant. In many cases, leaves of submersed plants are only a couple of layers thick and chloroplasts are very close to the epidermis. The thin leaves combined with aerenchyma tissue allows for rapid passage of gas from the exterior to the interior of the plant. Many aquatic plants have filamentous leaves which further facilitate the passage of gases between the cells.

Vascular Bundles

Vascular bundles are groups of specialized cells consisting of xylem and phloem, sometimes separated by a strip of cambium and arranged in different patterns. The presence of vascular bundles is not unique among aquatic plants, but aquatic plants characteristically contain vascular bundles. Vascular bundles are composed of phloem, tissue involved in the transport of carbohydrates and food materials, and xylem, woody tissue that is part of the water transport system. Vascular cambium, a lateral meristem that forms secondary tissue, is located between the xylem and phloem.

Stomates

In terrestrial plants, stomates allow for the passage of gases between the atmosphere and the plant, but stomates are of little use under water. Although stomates are found on many aquatic plants, these structures function in the passage of gases for emersed portions of the plant. Although submersed plants may have stomates, these appear to be largely non-functional. Both the upper and lower surfaces of emersed plants are covered with stomates. However, leaves of some emergent plants like cattail (*Typha* spp.) are vertical in position which makes it difficult to distinguish an upper and lower surface.

The stomates also allow for water loss by a plant. The extent to which the emersed portions of aquatic plants participate in the loss of water from an aquatic habitat is largely unknown. Many factors such as the abundance and type of aquatic plants influence the evapotranspiration from the surface of a body of water.

Support Tissue

Water, in combination with gas-filled aerenchyma tissue, provides support for many aquatic plants.

Since water helps support plants below the surface, the need for structural tissue is reduced. Emersed plants contain some support tissue, but aquatic plants in general lack the necessary structural material that allow them to grow to great heights. Sclerenchyma, tissue of uniformly thick-walled, dead cells in the stem, the principal function of which is mechanical, is either lacking or greatly reduced in aquatic plants. Idioblasts, plant cells containing oil, gum, calcium, or other products, help provide some mechanical support in aquatic plants, but these cells are not of a type that provide a significant amount of support.

Summary

All plants share common characteristics, but various groups of plants possess similar traits that allow them to live in a particular habitat. Flowering aquatic plants have several morphological and anatomical characteristics that allow them to live, grow, and complete their life cycle in and around water. Some of the traits exhibited by aquatic plants are similar to those exhibited by terrestrial plants living under heavy shade, but the feature of aerenchyma tissue is somewhat unique to aquatic plants. Aerenchyma tissue helps in the transport of gases and buoyancy for flowering aquatic plants.

Acknowledgements

Contribution of the University of Florida's, IFAS, Fort Lauderdale Research and Education Center. Published as Journal Series Number N-00615 of the Florida Agric. Exp. Sta.

Literature Cited

1. Sculthorpe, C. D. 1967. The Biology of Aquatic Vascular Plants. St. Martin's Press, N.Y. 610 pp.

Table 1. Classification of flowering, aquatic vascular plants with an example characteristic of each group (Sculthorpe, 1967).

A. Aquatic plants rooted in sediments
    1. Emergent plants - cattails (*Typha latifolia* L.)
    2. Floating-leaved plants
        a. With rhizomes or corms, and floating leaves on long flexible petioles - waterlily (*Nymphaea odorata* Ait.)
        b. With stolons and trailing stems ascending through the water and producing floating leaves on relatively short petioles - Banana lily (*Nymphoides aquatica* (S. G. Gmel.) Kuntze
    3. Submersed plants
        a. Caulescent types - hydrilla (*Hydrilla verticillata* (L.f.) Royle
        b. Rosette types - eelgrass (*Vallisneria americana* Michx.)
        c. Thalloid types - tropical Podostemaceae family

B. Free-floating aquatic plants
    1. Floating on surface - waterhyacinth (*Eichhornia crassipes* (Mart.) Solms
    2. Floating below the surface - bladderwort (*Ultricularia inflata* Walt.)

Torpedo Grass Biology and Control in a Draw-down Situation-1992

by Brian E. Smith, D. G. Shilling and W. T. Haller[1]

Torpedo grass (*Panicum repens*) is a rhizomatous, perennial grass which is found in aquatic and terrestrial habitats of the subtropics and tropics throughout the world. Torpedo grass was introduced to the United States from Australia in the early 1900s as potential forage grass in southeastern states. However, it was found that torpedo grass does not have the nutritive qualities of other improved grasses and interest in torpedo grass waned. Since introduction, it has become a serious weed in Florida and states along the Gulf Coast. In Florida, problems with torpedo grass include: infestations in golf courses, yield reductions in citrus groves, impeded water flow in irrigation and flood control canals, and displacement of native vegetation in wetland.

Biology

Sensitivity to prolonged cold temperatures limits the spread of torpedo grass northward. The extreme northern range of torpedo grass is southern Virginia. Seasonal cold periods will arrest the growth of torpedo grass until spring, at which time regrowth occurs from the rhizomes. Torpedo grass grows year 'round in areas with mild winters.

Torpedo grass grows aggressively in terrestrial and aquatic environments and quickly outcompetes other species and displaces native vegetation. In the terrestrial environment, torpedo grass grows in dense stands and the stems reach one to three feet in height. Torpedo grass grows best in low-lying areas with sandy loose soils and plentiful moisture. Ditch banks and lake shores are excellent habitat for torpedo grass. From the ditch banks and shorelines, vigorous rhizomes extend out on the surface of the water or along the bottom. Rhizomes (see Fig.1) are buoyant so those that grow on the water surface resemble elongated torpedoes, hence the common name "torpedo grass." Rhizomes that grow along the bottom produce shoots, which emerge above the water surface. Torpedo grass shoots can emerge from waters greater than eight feet deep. The principal means of spread for torpedo grass is vegetative reproduction from the vigorous rhizomes. The majority of the rhizomes grow in the top four inches of soil.

Figure 1 illustrates the basic morphology of torpedo grass. Torpedo grass shoots are rigid and have many nodes. Leaves are 2-6 inches long and may be smooth or slightly hairy, especially on the upper surface. Leaf sheaths loosely overlap with hairy margins. Ligules are membranous, ciliate, and approximately 1 mm long. The seedhead is terminal and open. Spikelets are ovate, glabrous and 2 to 5 mm long. Seeds are nonviable. Rhizomes are ¼ - ½ inch in diameter and reach lengths > 30 feet. Axillary buds are found along the entire length of the rhizome.

Management

To effectively control a perennial weed such as torpedo grass, the underground reproductive organs (rhizomes) must be killed. To do this herbicides must be absorbed and translocated to the rhizomes in amounts that are phytotoxic. Herbicides which are not translocatable, diquat for example, only kill the foliage, which allows regrowth to occur from the unaffected rhizomes. The herbicide glyphosate has been extensively used to control torpedo grass. It is sold under the trade name Roundup® and others for terrestrial use and Rodeo® or Pondmaster® for aquatic applications. Glyphosate is a nonselective, foliar-applied, translocatable herbicide with no soil activity. Generally, glyphosate provides excellent control of many perennial species, however, the complete control of torpedo grass rarely ocurs and repeat applications are necessary.

Why doesn't a single application of glyphosate provide complete control of torpedo grass? There are three possible explanations.

First, torpedograss rhizomes have numerous buds along the entire length of the rhizome. Many of the buds are not actively producing shoots or rhizomes. These inactive buds are not dead but are dormant. Sugars, produced by the plant for food during photosynthesis, termed photosynthates, move from the site of production to areas in the plant that are actively growing, termed sinks. Glyphosate moves with the photosynthates. Inactive buds are not strong sinks and therefore do not receive a lethal dose of the herbicide. After the herbicide treatment, the buds become active and reestablish torpedo grass.

Secondly, in some cases, the leaves may not absorb and translocate glyphosate to the rhizomes in sufficient quantities. For example, torpedo grass in standing water will have only a small portion of the foliage emergent and this limits the amount of contact with the herbicide.

[1]University of Florida, Institute of Food and Agriculltural Sciences, Dept. of Agronomy, Center for Aquatic Plants, Gainesville, FL

Thirdly, the time of application may influence the effectiveness of glyphosate. During the growing season, plants differentially allocate photosynthates in the plant. For example, research has shown that in the fall torpedo grass, as do other perennial species, translocates much of the photosynthates to the rhizomes for storage over the winter. This natural time of downward flow offers an excellent opportunity to move more glyphosate into the rhizomes thus potentially giving more control.

Torpedo Grass Control During Low Water Periods

The control of torpedo grass has proven to be more difficult when it is partially submerged. Torpedo grass flourishes in the shallow water perimeters of many Florida lakes. But, lake levels fluctuate naturally or are controlled artifically. When lake levels are low, torpedo grass growing around lake fringes becomes exposed. These particular times present an exceptional opportunity for intensive torpedo grass control. The recommendations listed below are given for the control of torpedograss during low water periods. Each recommendation is prefaced by a scenario. Scenarios are given so that under various conditions the recommendation optimizes the control of torpedo grass in terms of long-term management. The management practices of burning or mowing, disking and herbicide treatments are used in various combinations depending on the particular scenario.

Controlled burning efficiently removes foliage and dense thatch which allows the disking to be more effective. Stems have the capacity to regenerate if sprigged in during disking; burning minimizes this. Also, if burning is complete prior to the last cold period, the insulating qualities of the thatch are removed and rhizome damage may occur due to exposure to cold temperatures.

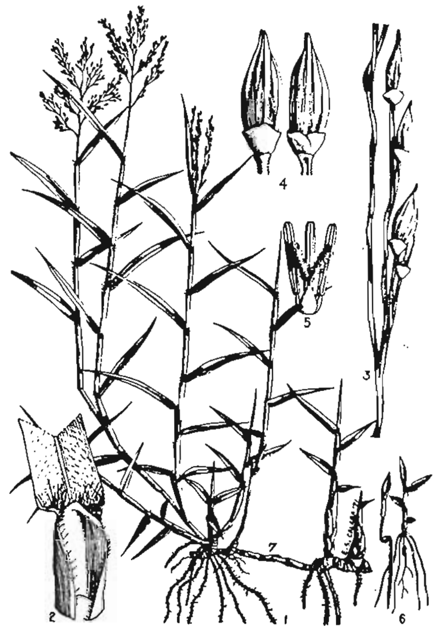


Fig 1. Panicum repens *L. 1, habit; 2, ligule; 3, portion of spike; 4, spikelet, two views; 5, flower; 6, seedling; 7 rhizome.*

If a controlled burn is not possible, mowing may be substituted for burning. Mow the torpedo grass close to the ground and allow the cut foliage to dry completely before disking.

Disking not in conjunction with herbicide treatments will facilitate the spread of torpedograss. Disking must be done thoroughly. After disking the majority of the rhizome sections should be less than four inches. Bury the rhizomes as deep as possible since this will help reduce the torpedograss population by over seventy five percent. This control will be quickly lost without the application of a herbicide since torpedo grass can rapidly reestablish. In addition to reducing density of torpedo grass, disking will induce previously inactive buds on the rhizome to become active and produce shoots. This provides sites-of-entry and an active sink in the rhizome for the herbicide.

Herbicide rates and timing of application are given to insure the best control of the least cost given the particular scenario.

Keep in mind that though the torpedo grass to be treated is on dry land, the area is still considered an aquatic site. Appropriately labelled glyphosate is registered for aquatic applications. In each case it is advisable to use the least amount of diluent carrier volume necessary.

Scenario 1: Water levels have fallen in the fall or winter and are expected to remain low through the spring of the following year. Torpedo grass foliage is brown due to cold temperatures and a controlled burn or mowing is possible. Disking equipment is available.

Recommendation: 1) Burn off the foliage as early as possible. 2) Allow torpedo grass to regrow until the new shoots are 4-6" tall. Then disk the area *thoroughly*. 3) At least two weeks prior to the first frost or cold weather, apply glyphosate at a rate of one to two pounds per acre. 4) The following year, prior to rising water levels, apply one to two pounds per acre glyphosate to the surviving torpedo grass.

Scenario 2: The water level has dropped in the fall or winter and is expected to remain low through the spring of the following year. Neither controlled burning nor mowing are possible.

Recommendation: 1) Apply two pounds per acre glyphosate in the spring two to four weeks after the torpedo grass begins to regrow. 2) Apply two pounds per acre glyphosate at least two weeks prior to the first cold weather. 3) The following year prior to rising water apply one to two pounds per acre glyphosate to the surviving torpedo grass.

Scenario 3: The water level has fallen in the fall or winter and water levels are expected to rise by the fall. Torpedo grass foliage is brown due to cold temperatures and a controlled burn or mowing is possible. Disking is possible.

Recommendation: 1) Burn then thoroughly disk the area as early as possible. 2) Allow torpedo grass to regrow until the new shoots are four to six inches tall and apply one pound per acre glyphosate. 3) Two weeks prior to the first cold temperatures or just before the water level rises, apply two pounds per acre glyphosate.

Scenario 4: The water level has dropped in the fall or winter and water levels are expected to rise by the fall. Neither a controlled burn nor mowing are possible.

Recommendation: 1) In the spring, two to four weeks after the torpedo grass begins to regrow, apply two pounds per acre glyphosate. 2) Apply two pounds per acre glyphosate as late as possible but at least two weeks prior to frost or cold weather.

Scenario 5: The water level has fallen in the spring or summer and is expected to remain low through the fall but will rise by spring. Torpedo grass is actively growing and mowing is possible. Disking is possible.

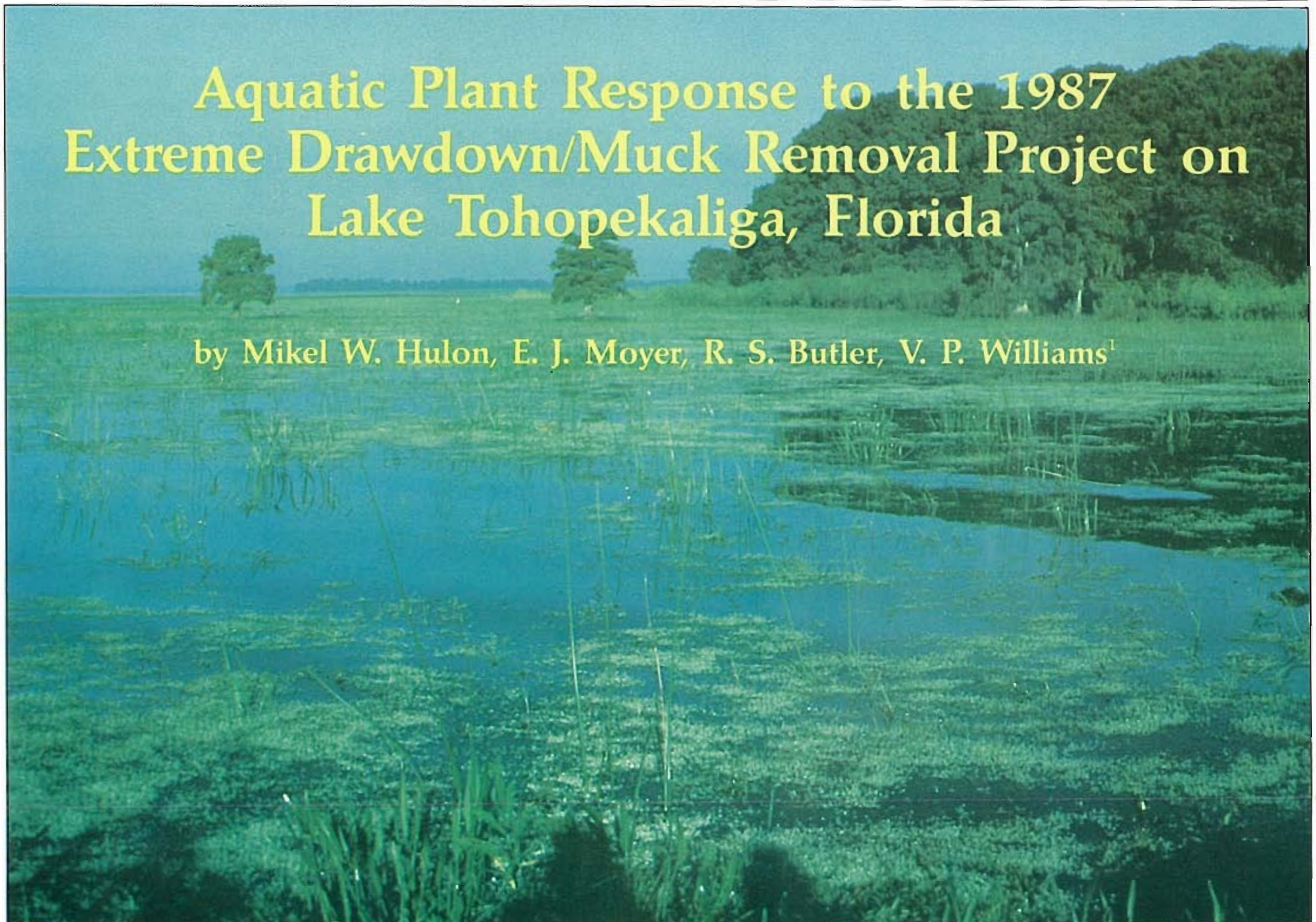
Recommendation: 1) Mow the area as early as possible and allow the cut foliage to completely dry. 2) Disk the area thoroughly just after the foliage has dried. 3) Apply two pounds per acre glyphosate as late as possible but at least two weeks prior to frost or cold weather.

Scenario 6: The water level has fallen in the spring or summer and is expected to remain low through the fall but will rise by spring. Torpedo grass is growing but mowing is not possible.

Recommendation: 1)Apply two pounds per acre glyphosate in the spring. 2) Apply two pounds per acre glyphosate as late as possible but at least two weeks prior to frost or cold weather.

Aquatic Plant Response to the 1987 Extreme Drawdown/Muck Removal Project on Lake Tohopekaliga, Florida

by Mikel W. Hulon, E. J. Moyer, R. S. Butler, V. P. Williams[1]



South Steer Beach, Transect IV, Fall 1988, after muck removal

Abstract

Organic build-up of detrital plant material has accumulated in shallow littoral areas of Lake Tohopekaliga, creating a low water berm and isolating hundreds of hectares of productive fish and wildlife habitat. An extreme drawdown and muck removal project was conducted in the spring of 1987 to restore aquatic habitat. Vegetation transects (percent composition) were surveyed during November of 1986, 1987, 1988 and 1989 at four sites on muck removal areas to document changes in aquatic plant communities. Aquatic plants present at each transect shifted dominance and species diversity during the study period from November 1986 through November 1989. In 1989, three years after restoration, plant densities on restoration sites decreased dramatically. Scraped areas were allowed to revegetate naturally and provided prime habitat for sportfish and forage production.

[1]Division of Fisheries, Florida Game and Fresh Water Fish Commission, Kissimmee, Florida.

Background

Lake Tohopekaliga is a 22,500 acre lake located in the upper Kissimmee River Basin, Osceola County, Florida. The lake is very productive and supports a quality sport fishery. In spring 1990 (February through May), fishermen expended 130,000 man-hours of effort for sportfish on Lake Tohopekaliga (Moyer et al. 1991). Desirable aquatic habitat maintained and enhanced by three extreme drawdowns has been the key to managing this as a productive lake.

Excessive, secondarily-treated sewage effluent, over 22 million gallons per day, was discharged into the lake basin from the late 1950's until 1988, when all discharges were stopped. High nutrient loading and regulated water levels negatively affected the aquatic plant communities and overall lake productivity (Holcomb and Wegener, 1971). Increased algal growth and nuisance aquatic plants contributed flocculent material and debris to the lake bottom. Extreme drawdowns were implemented to counteract these negative impacts. The first extreme drawdown was completed on Lake Tohopekaliga in 1971 and the program repeated in 1979 and 1987. An organic build-up, composed of plant detritus, near regulated low pool stage was first documented by project biologists during the 1971 drawdown (Wegener, pers. comm.). This material continued to accumulate through time, forming a low water berm that isolated hundreds of hectares of shallow littoral habitat.

An extreme drawdown and muck removal project was completed in 1987. The organic material and plant communities associated with the low water berm were mechanically removed from four sites following the drawdown (Moyer et al. 1989). A total of 335 acres were restored during 1987 at a total cost of $446,705. The objective of this study was to compare percent presence of aquatic plant species sampled before and after the restoration project.

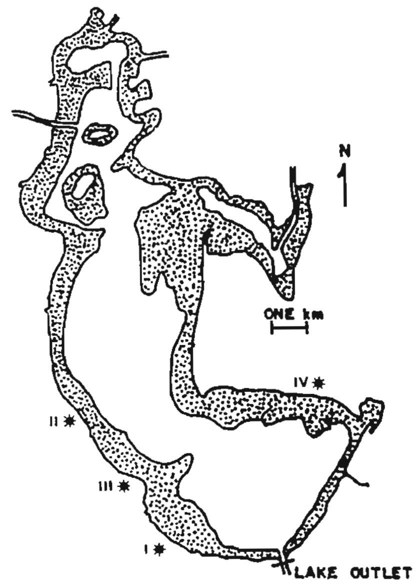
Methods

Vegetation transects were established at muck removal sites around Lake Tohopekaliga (Figure 1) to determine percent composition of plant species in the shallow littoral zone. Four transects were sampled during November 1986, prior to implementation of muck removal project, and again in November 1987, 1988 and 1989 following muck removal. Transects bisected the restored areas and were comparable in length to the width of lake bottom scraped. Transect lengths were 256, 189, 157 and 138 ft. for Transects I-IV, respectively. Vegetation samples were collected at three-meter intervals along the transects. Three samples were taken at each interval: two were perpendicular to the line and located one meter on either side, while the third was on the transect line. A 7 ft. long steel pole with three hooked rods, each 0.12 inch in diameter and 1.5 inch in length, attached at one end (called a frotus) was used to collect samples. All plant species hooked by the frotus were identified and recorded. Plants were identified using the Identification Manual for Wetland Plant Species of Florida (Dressler, et al. 1987). A Manual of Aquatic Plants (Fassett, 1960), Aquatic Plants of the United States (Muenscher, 1944) and Aquatic and Wetland Plants of Florida (Tarver, 1979). Data were summarized to show plant species percent composition along each transect line. A listing of common and scientific names for 36 plant species collected during the study period is presented in Figure 2.

South Steer Beach, Transect IV, Fall 1986 pre-muck removal.

Remarks

Vegetation present at Transect I in 1986 primarily consisted of smartweed (*Polygonum* spp.; 20%), pickerelweed (*Pontederia cordata*; 18% and alligator weed (*Alternanthera philoxeriodes;* 14%). These species formed dense stands of vegetation rooted in an organic substrate that was is excess of one foot in depth. The transect area had been dry for nearly nine months prior to sampling in November 1987. Plant speies pre-



* DENOTES SAMPLE SITE LOCATIONS

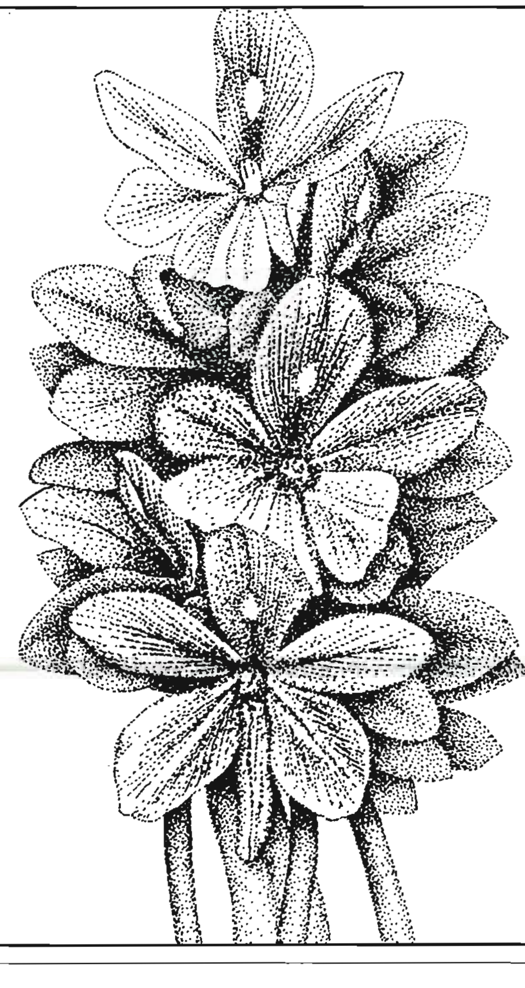
NOTE: STIPPLED AREA REPRESENTS LITTORAL ZONE

Figure 1. Location of four vegetation transects on Lake Tohopekaliga.

sent in 1987 consisted of semi-aquatics such as coinwort (*Centella asiatica*; 1%), sedge (*Cyperus* spp.; 6%), common wildmillet (*Echinochloa crusgalli*; 1%), dog-fennel (*Eupatorium* spp.; 12%), rush (*Juncus* spp.; 10%), water primrose (*Ludwigia* spp.; 1%), water paspalum (*Paspalum repens*; 19%) and sesbania (*Sesbania* spp.; 1%). The majority of these plants were submerged following reflooding and did not survive into 1988 and 1989. By 1989, smartweed, pickerelweed and alligator weed were replaced by spikerush (*Eleocharis* spp.) 23%, torpedograss (*Panicum repens*) 21% and watergrass (*Hydrochloa caroliniensis*) 20%. These desirable species were rooted in hard sand substrate and formed a more productive area for sport fish reproduction. Although species diversity averaged 15 species per year, 30 species were documented at Transect I over the four-year period. Observed plant density at Transect I during 1987 through 1989 was dramatically lower than pre-muck removal plant density in 1986. Lower plant density and the removal of the organic berm allowed for the movement of shallow water fish and invertebrates throughout the entire littoral zone.

Diversity at Transect II ranged from 11 species in 1986 to 10 in 1989, four of which were common to Transects I and II. During the four year sampling period, 22 different species were sampled at Transect II. The plant community at Transect II in 1986 predominantly consisted of pickerelweed (16%), para grass (*Brachiaria mutica*; 14%), water primrose (14%), alligator weed (13%) and smartweed (12%). By 1989, Transect II plant communities primarily consisted of five species: hydrilla (*Hydrilla verticillata*; 21%), watergrass (21%), alligator weed (18%), pickerelweed (18%) and smartweed (15%). Although hydrilla, alligator weed and smartweed are three of the top four plant species present at Transect II fisheries data collected by electrofishing, showed to be more productive than adjacent areas where restoration did not occur (Moyer et al. 1989).

Data collected at Transect III showed alligator weed and smartweed combined to represent over 55% of the vegetation present in fall 1986. In 1987, plants such as sedges, buttonweed (*Diodia virginiana*), common wildmillet, dog-fennel and water paspalum encroached upon the cleared and exposed lake bottom. These species could not withstand reflooding and declined to a very low percentage by 1989. Spikerush, water grass and torpedograss all increased in percent composition from 1987 to 1989. An average of 11 species were present during each fall sampling period; of these, only three (alligator weed, torpedograss and smartweed) were present during all four sampling periods. A total of 20 species were collected during the study. Spikerush, watergrass and torpedograss together constituted over 78% of the vegetated community sampled by fall 1989. The substrate has remained firm and sandy since muck removal with very little



Species	Common Name
Alternanthera philoxeroides	Alligator weed
Bacopa spp.	Water-hyssop
Brachiaria mutica	Para grass
Centella asiatica	Coinwort
Ceratophyllum demersum	Coon-tail
Cyperus spp.	Sedge
Diodia virginiana	Buttonweed
Echinochloa crusgalli	Common wildmillet
Eichhornia crassipes	Water-hyacinth
Eleocharis spp.	Spikerush
Eupatorium spp.	Dog-fennel
Hydrilla verticillata	Hydrilla
Hydrochloa caroliniensis	Watergrass
Hydrocotyle umbellata	Floating pennywort
Juncus spp.	Rush
Lippia spp.	Frog-fruit
Ludwigia spp.	Water-primrose
Micranthemum umbrosum	Baby-tears
Najas guadalupensis	Southern naiad
Nelumbo lutea	Lotus
Nymphaea ordorata	Water lily
Nymphoides aquatica	Floating hearts
Panicum hemitomon	Maidencane
Panicum repens	Torpedo grass
Paspalum distichum	Knot-grass
Paspalum repens	Water paspalum
Pistia stratiotes	Water-lettuce
Polygonum spp.	Smartweed
Pontederia cordata	Pickerelweed
Sagittaria spp.	Arrowhead
Scirpus americanus	Three square
Scirpus californicus	Giant bulrush
Sesbania spp.	Sesbania
Typha spp.	Cat-tail
Utricularia spp.	Bladderwort
Vallisneria americana	Eel-grass

Figure 2. A checklist of plant species encountered in vegetation transects of Lake Tohopekaliga in November 1986, 1987, 1988 and 1989.

deposition organic overlay present. Spawning conditions for gamefish have remained excellent.

Plant species at Transect IV responded favorably to muck removal. In 1986, the dominant plants were pickerelweed, smartweed and alligator weed, representing 59% of the sampled plant community (Table 4). Only eight species were collected in fall 1987, following the muck removal project, a decrease from the 11 species present in fall 1986. Sedges, common wildmillet, and water paspalum were not present in 1986 but occurred in 37% of the samples in 1987. By fall 1989, species diversity totaled 11 species, similar to pre-muck removal estimates. The prevalent plant species were watergrass (35%) and spikerush (17%). Hydrilla occurred in 13% of the samples collected in fall 1986 and increased slightly to 16% by fall 1989. Hydrilla has spread throughout littoral areas of the lake since the early 1970s and recent hydrilla expansion would likely have occurred with or without the drawdown/muck removal project.

When water level fluctuations are restricted in lake systems with high nutrient levels and aquatic plants are allowed to establish monocultures, the availability of prime, shallow water, littoral habitat (3 ft in depth) rapidly decreases and sportfish populations decline. On large lakes, mechanical removal of organic material in conjunction with extreme drawdowns has helped revitalize aquatic habitat. This procedure is expensive ($1300-1500 per acre) and labor intensive, but the results have proven beneficial. Management programs of this type will continue throughout the upper Kissimmee Chain of Lakes.

South Steer Beach Transect IV, Spring 1987, during muck removal.

AquaVine

FAPMS 1992 Annual Meeting
Call for Photo Contest
Call for Entertainment

The FAPMS 1992 annual meeting will be held 27-30 October at the Holiday Inn Surfside in Clearwater Beach. Registration cards that were mailed to all members in August give all the details. Get your best photos of natural scenes or operations printed in 8×10 inch size and bring 'em for the photo contest. And remember,the challenge has been given for even newer, even better, even zanier banquet entertainment to be devised. Get out your clown suits, put on your grease paint, and break your legs!

FAPMS Helps APMS Meeting Succeed

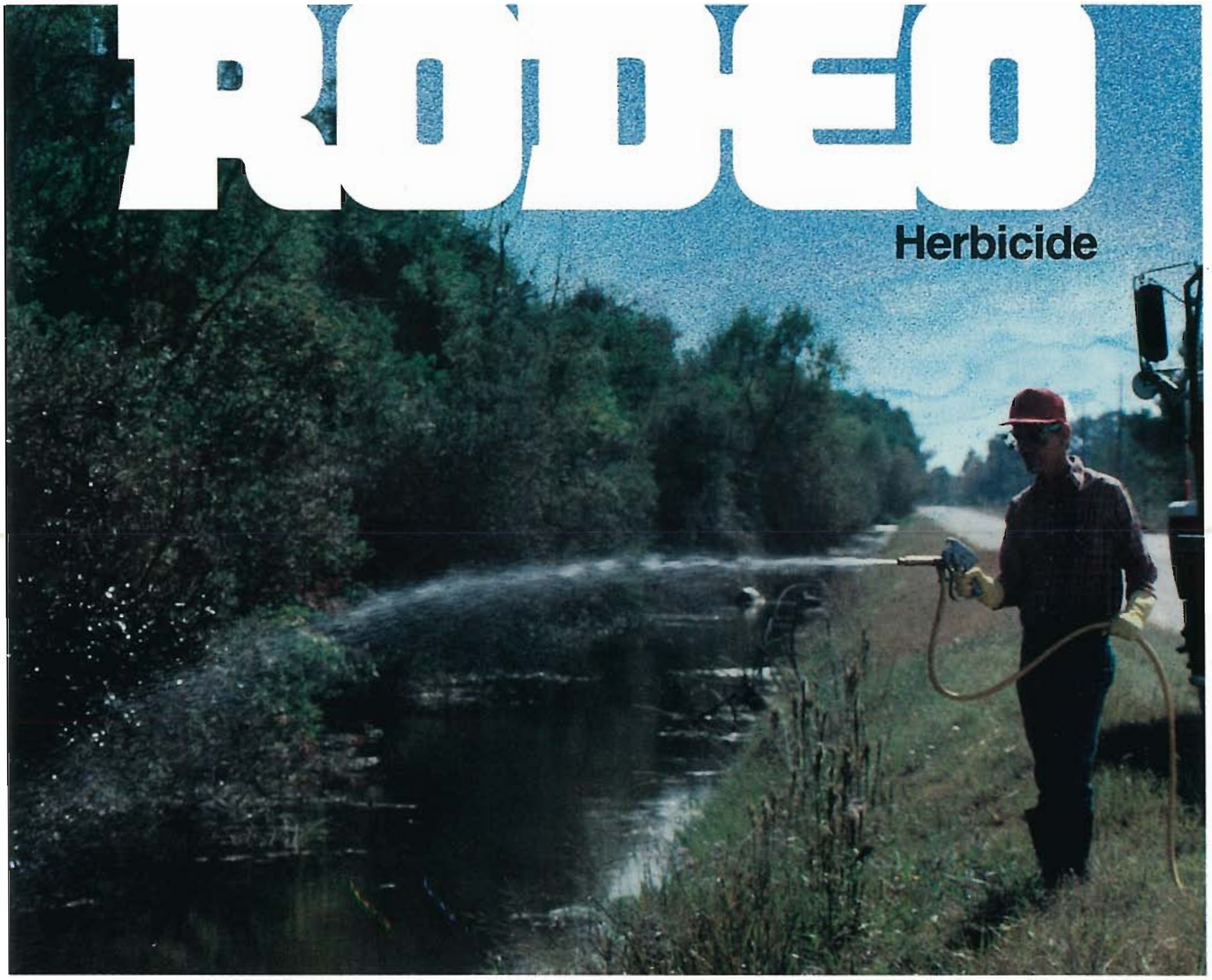
FAPMS was well represented at the APMS annual meeting and international symposium in Daytona Beach, 12-16 July, 1992. FAPMS made a financial contribution to the meeting as well as providing everyone with a zippered pouch to hold their registration material, the June issue of "Aquatics" magazine and other assorted goodies. Happy registrants were seen leaving the exhibit area (where the FAPMS booth was displayed) clutching their bulging FAPMS pouches.

Florida members were active in organizing local arrangements and Nancy Allen and Greg MacClain procured and sold special symposium T-shirts, providing an added $200 for the FAPMS William Maier Scholarship Fund. FAPMS contributions continued even after the closing session of talks, as various members helped make the two post-symposium field trips into great successes.

Upcoming Meetings

Sept 11-12 — National Horticulture Short Course, Orlando, FL. Contact: Uday Yadav, (407) 323-2500.
Sept 30-Oct 2 — Midsouth Aquatic Plant Management Society 11th annual meeting, Guntersville AL. Contact: Randell Goodman, (205) 844-4786.
Oct 2-3 — Minnesota Lakes Association annual meeting, Minneapolis. Contact: Pat Wulff, (612) 479-2972.
Oct 27-30 — Florida Aquatic Plant Management Society annual meeting, Clearwater Beach, FL. Contact: Ken Langeland (904) 392-9613.
Oct 28-30 — Natural Areas Association 19th annual conference, Bloomington, IN. Contact: NAC registration, (812) 855-6451.
November 2-7 — North American Lake Management Society annual symposium, Cincinnatti, OH. Contact: Lorraine Duncan, (904) 462-2554.
November 10 — Texas Aquatic Plant Management Society annual meeting, Victoria, TX. Contact: Joyce Johnson, (512) 389-4858.

HOW TO CONTROL BRUSH AND WEEDS IN AND AROUND WATER.



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