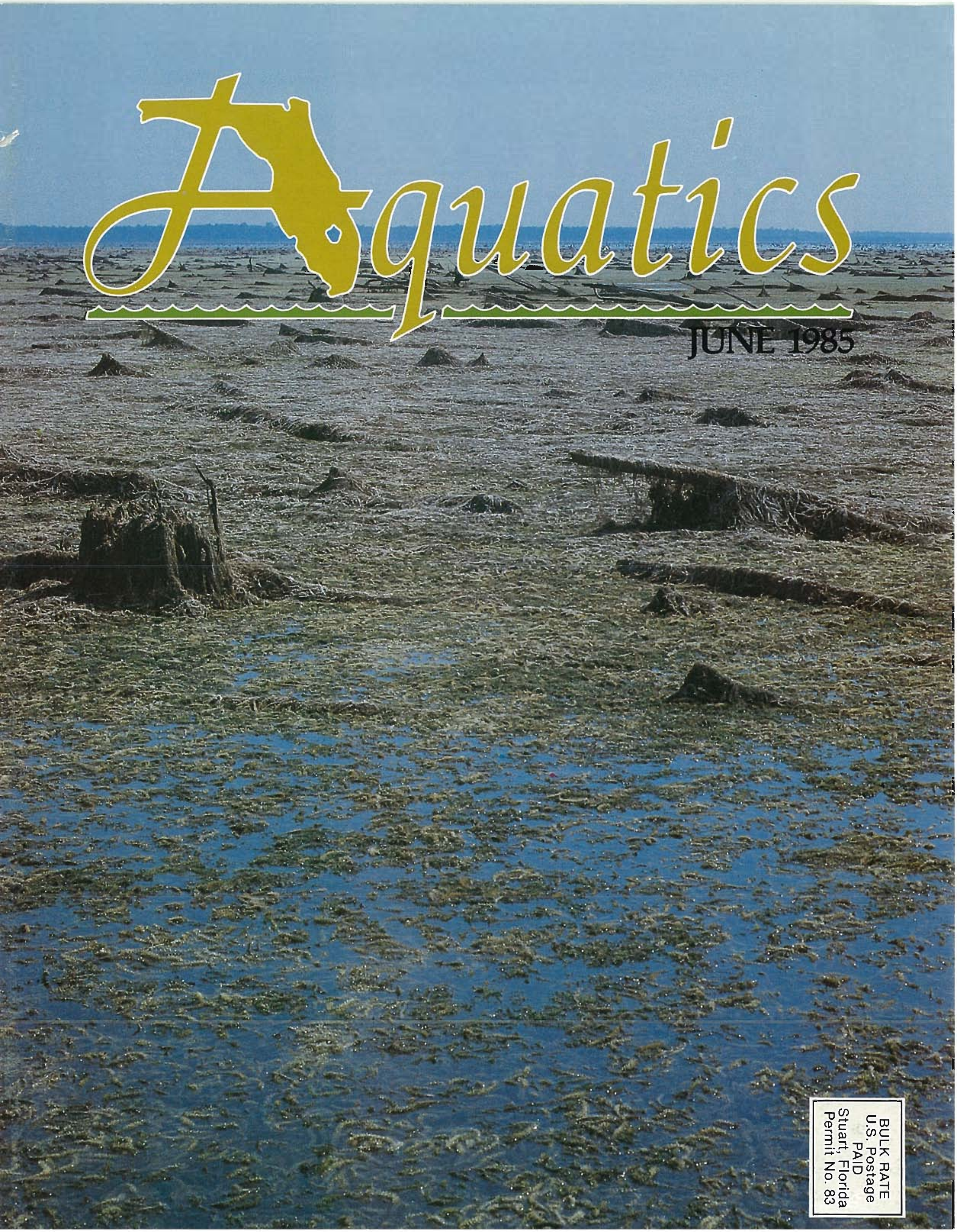
Aquatics

JUNE 1985



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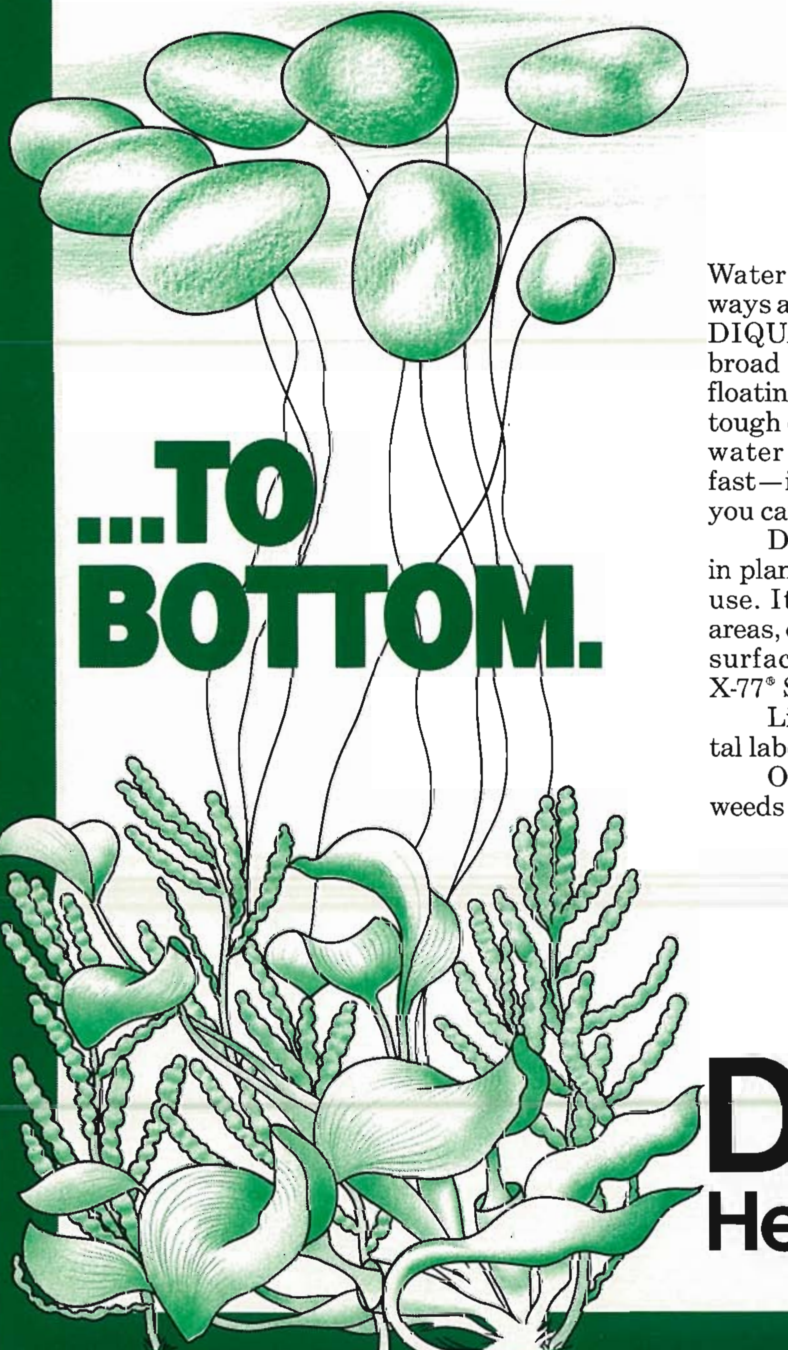

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EDITORIAL

by Roy P. Clark, Chief
Pesticides and Toxic Substances

Law may be defined as the principles and regulations established by a government and applicable to a people. Theodore Roosevelt once said, "No man is above the law and no man is below it; nor do we ask any man's permission when we require him to obey it. Obedience to the law is demanded as a right; not asked for as a favor."

Enforcement of the various laws is a service we should insist be implemented. The better the enforcement the better the service. Enforcement is a service?

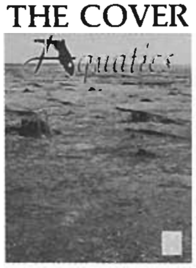
Let us consider some of the various laws related to aquatic plant management and decide.

Permits are required before public waters may be treated. Enforcement is a service to the public as a whole by assuring the most acceptable method of control is designated. It is a service to the applicator by separating the knowledgeable from the nozzlehead. It is a service to the manufacturer of a product by assuring the item to be used is one which has been tested and accepted for the specified use. It is a service to the law abiding, conscientious and/or dutiful by insisting all must proceed in a similar manner.

Enforcement of the use of a registered pesticide in an approved manner is a service to the manufacturer by assuring only tested and accepted products on which the registrant has spent valuable resources is used; it eliminates unfair competition. It is a service to the bona fide applicator by assuring application is made correctly; again protection of unfair competition. It is a service to the public by assuring the environment receives the most benefits with the lowest risks.

In brief, a good enforcement program protects the law abiding by compelling the "guilty" to conform. A good enforcement program causes unjust, unenforceable or other uncalled for laws to be amended or removed. In 1770, William Pitt said, "Where laws end, tyranny begins." He could have added "without enforcement, there is no need for laws; except the law of the jungle."

ABOUT THE COVER



Exposed hydrilla as a result of a planned drawdown of Rodman Reservoir, Putnam County, in 1980. Photo by: Dave Bowman Corps of Engineers Palatka, Florida

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CONTENTS

AQUATICS: Published quarterly as the official publication of the Florida Aquatic Plant Management Society. This publication is intended to keep all interests informed on matters as they relate to aquatic plant management, particularly in Florida.

EDITORIAL: Address all correspondence regarding editorial matter to Daniel Thayer, Editor, "Aquatics" Magazine, 7922 N.W. 71st Street, Gainesville, FL 32606.

Coontail (*Ceratophyllum Demersum* L.)

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INTRODUCTION

The name *Ceratophyllum* derives from the Greek 'keras' horn and 'phyllon' leaf. *Ceratophyllum demersum* commonly called 'coontail' (United States) or 'hornwort' (Great Britain, Australia, New Zealand) was first described by Linneaus in 1753. It belongs to the dicotyledonous family Ceratophyllaceae which contains only a single genus. The species of *Ceratophyllum* are variable and difficult to identify (2). More than 30 species have been described, but only three are recognized as valid, viz. *Ceratophyllum demersum* L.,*C. muricatum* Cham., and *C. submersum* L. (8).

DESCRIPTION

Coontail *(Ceratophyllum demersum)* is a perennial, entirely submerged plant with slender, elongated stems and numerous lateral branches. The length of the plant can range from a few centimeters up to 4 meters (1 inch-13 feet). The stems and foliage are sometimes rough to touch and might be stiff and brittle. The leaves are whorled and crowded near the tip of the branches which gives the plant its 'coontail' appearance. Unlike most submerged aquatics, it does not develop roots. However, sometimes leafy branches are modified as 'rhizoids' ('holdfasts') and serve as anchorage (6).

The leaves are whorled, 1-4 cm long, with 9-11 at a node. The leaves are 1 to 4 times dichotomously forked and have 2-4 leaf segments which are toothed at each side (4).

The flowers are very small, unisexual and each surrounded by minute bracts. A real perianth is not present. Usually there is only one flower in the axil of each leaf in a whorl. The male flower has numerous stamens which are on a common stalk. The female flower has one sessile ovary. The fruit is a one-seeded nut, ellipsoid, about 4-6 mm long and black in color. It has 3 soft spines which are much longer than the fruit body. The apical spine (the persistent style) is 11 to 12 mm long, the two basal ones slightly shorter. Occasionally one or both of the basal spines are only partially developed (6,7,10).

BIOLOGY

The botanist Arber (1920) described coontail as "a plant in which the aquatic habit has reached its ultimate expression"(1). It lives entirely submerged through all phases of the life cycle and is well adapted to the aquatic environment. About 86-95 percent of the plant is water and one-third of the tissue consists of air spaces (6). There is a complete absence of lignification. When one removes the plant from the water it doesn't collapse and dry out as quickly as many of the other submerged plants.

Coontail reproduces either vegetatively by fragmentation (A) or sexually by seeds (B).

(A) Vegetative propagation seems to be the main method of reproduction. It is easily achieved by the breaking off of larger plants, branches or tips.

(B) Pollination takes place under the water surface. The mature stamens detach from the plant and rise to the surface with the help of small terminal floats. On the water surface the stamens burst open. The pollen is heavier than water and sinks slowly where it reaches the stigmas of the female flowers. Fertilization takes place and seeds develop. At maturity the seeds quickly sink to the bottom where they germinate. Germination, however, may be delayed until favorable conditions exist (e.g. high water temperatures). When the seedlings reach about 8 cm in length they may become buoyant and rise to the water surface (7).

The plant goes through a period of winter dormancy. In fall when the temperatures drop the plant forms thick lateral tips which are dark green and contain an increased amount of starch. The stems become quite brittle and fragmentation takes place. The fragments lose their buoyancy, sink to the bottom, become dormant, lie on the bottom and gradually become covered with sediment. When the water temperature rises new shoots develop from branch buds (so called 'winter buds') which have remained dormant in the leaf axils (7).

Vegetative shoots may grow under ice, but immersion for 5-6 days would kill the plant. The minimum temperature for rapid growth of coontail is about 20°C (68°F) (14).

HABITAT AND DISTRIBUTION

The plant inhabits stagnant, still to slowly flowing waters of rivers, ponds, lakes, ditches and canals. It was also recorded once growing in brackish waters. It usually exists as large floating mats near the water surface.

Coontail favors water with high alkalinity (pH 7.1 to 9.2) and it is known to tolerate low light intensities (6). It is considered to grow best in waters which are high in nitrogen (5). This might explain why coontail can be very abundant in drainage canals of agricultural areas.

Coontail is found throughout the world except in the colder regions. It is native to the United States and is widely distributed in Florida. According to the D.N.R. Aquatic Plant Survey of 1983 it covered 11,406 acres of Florida's freshwater (12). It was most abundant in lakes (10,236 acres). The highest plant density namely 6,129 acres was observed in Lake Okeechobee which represents 54% of all coontail found in the survey. Coontail was the sixth most abundant plant in rivers (979 acres), and it occurred in 19% of the canals surveyed (191 acres).

SIGNIFICANCE

Coontail plays an important part in the food chain of many aquatic animals. It is readily eaten by invertebrates and its foliage provides habitat for small fish and insects beneficial to fisheries. The seeds are sought by diving ducks (10).

Fig. 1. Coontail (Ceratophyllum demersum) *has slender, elongated stems and whorled leaves.*

In Florida, coontail appears to be a minor problem, however, moderate water use restrictions caused by the plant occurred in rivers and canals of Citrus and Sarasota Counties (12).

In New Zealand coontail is a serious weed in lakes supplying water to hydro-electric power plants, and in Australia it interferes with water flow, fishing and water sport activities (11).

CONTROL

Mechanical harvesting of coontail is reported to increase the density of plants (9). Two pounds per acre of Diquat and 1-2 ppm sodium or potassium salt of Endothall (liquid or granular) are recommended for controlling coontail (13).

In small ponds in Puerto Rico and Florida *Marisa cornuarieties* L., a large freshwater snail eradicated a variety of submerged aquatics, including coontail. Recently a migratory endoparasitic nematode, *Hirschmanniella caudacrena*, has been found abundantly in coontail populations of Newnans Lake and Rodman Reservoir (3). The main field symptom of nematode infection is a discoloration of the plant,

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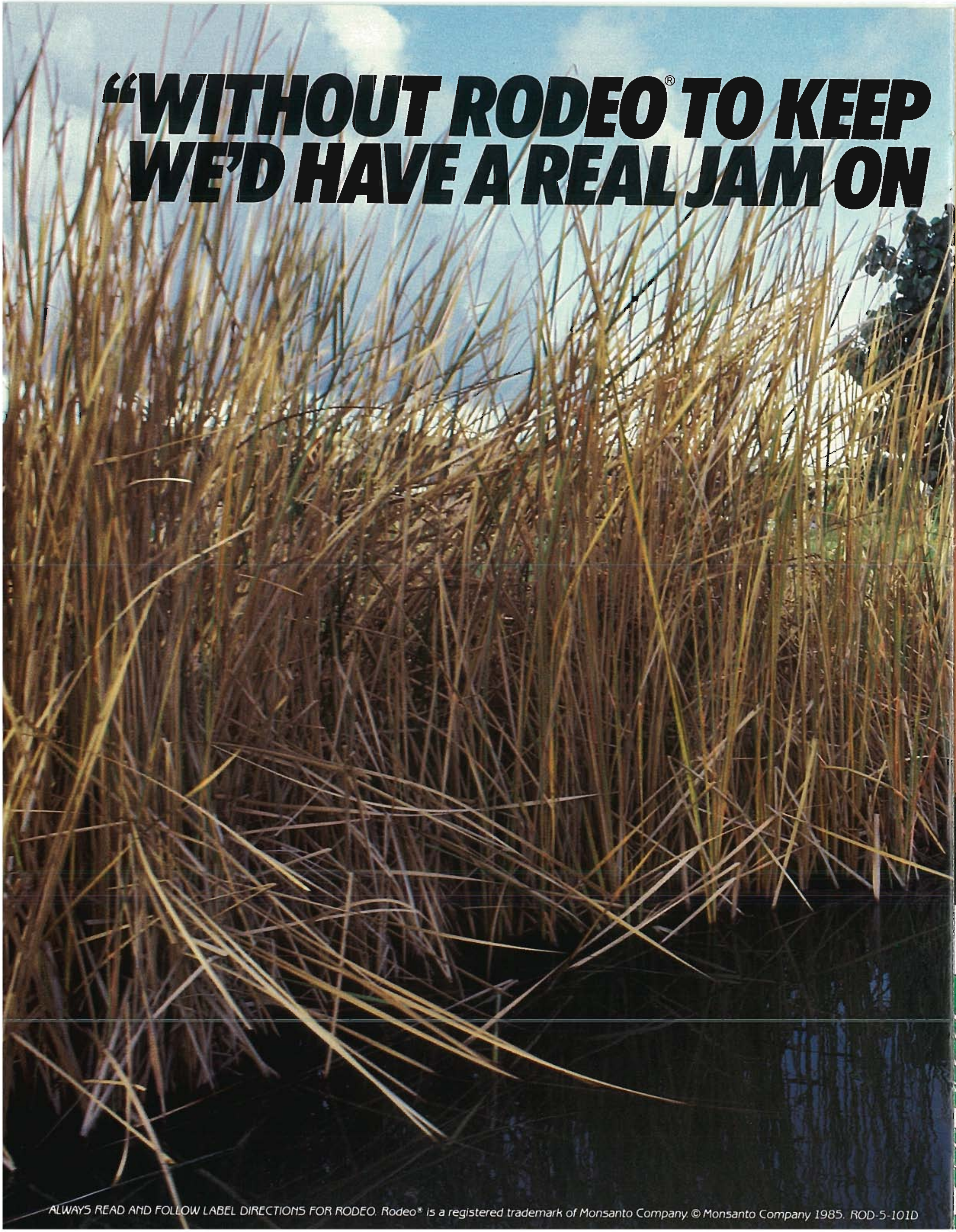
"WITHOUT RODEO® TO KEEP
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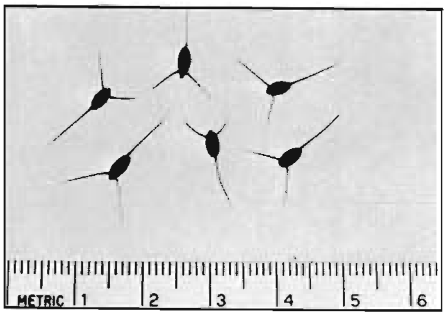

Fig. 2. Three-spined fruits are typical of Ceratophyllum demersum.

mainly a yellow to light orange-brown color. Laboratory tests showed that the nematode is pathogenic to coontail and the suitability of the nematode for biocontrol purposes is being further evaluated.

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The Effects of a Large Scale Fluridone Treatment on the Vegetation of Sampson Lake

by Joe Hinkle

I. Introduction

Sampson Lake is a 2,042 acre lake located west of Starke in North-central Florida which drains 64 square miles of Bradford County. The average depth is seven feet with a maximum of fourteen feet. The shoreline perimeter is 6.5 miles. Sampson Lake has a hard sand bottom with minimum organic deposits, a pH of 6.4-6.6, total calcium carbonate hardness of 55 ppm, and secchi disc readings of 5-6 feet. Canals connect Sampson Lake to Crosby and Rowell Lakes which are also major public water bodies of the region. Water discharges from Sampson Lake through Sampson Creek into the Santa Fe River.

Hydrilla *(Hydrilla verticillata)* was first discovered in Sampson Lake in the fall of 1977. The plant originated from a population in Alligator Creek three miles away at Starke. Hydrilla spread downstream becoming established in Rowell Lake and eventually was transferred through the connecting canal to Sampson Lake, establishing on the southeast side. In 1982, hydrilla coverage increased drastically to approximately 1,100 acres creating navigational and recreational usage problems. The water level rose in late 1982 and approximately 300 acres of hydrilla were shaded out by extremely tanic water in the deeper portion of the lake. In the fall of 1983 a total of 1,110 acres or 54% of the lake was covered with 27 species of aquatic plants. Hydrilla occupied 800 acres, or 39% of the lake. Native plants were present only around the perimeter in water depths less than four feet. Hydrilla had extended from shallow openings in the native vegetation to the eight foot contour of the lake crowding out native submersed species, forming a monoculture in 72% of the vegetated areas of the lake.

Sampson Lake supports one fish camp, has two public boat ramps, and many private homes located along the eastern and southern shorelines. The primary use of the lake is recreational fishing. Fishing values obtained from the Florida Game and Fresh Water Fish Commission (GFC) creel surveys indicate a yearly value of $130,725 for Sampson Lake. These estimates include trip expenditures and values of fish caught by anglers.

Along with decreased recreational usage created by large acreages of topped-out hydrilla, blocknet samples conducted in Sampson Lake by the GFC indicated that these areas supported considerably less harvestable sport fish than other types of habitat available in the lake.

II. The Management Program

The major objectives of the Suwannee River Water Management District control program were:

(1) Provide maximum control of hydrilla in recreational and navigational areas;
(2) Protect existing native vegetation;
(3) Encourage reestablishment of, or transplant native vegetation to provide competition with hydrilla.

A total of 200 acres of the 800 acres of hydrilla were selected for treatment using the herbicide fluridone. The largest plot, covering 75 acres was located on the eastern side adjacent to several homes, a fish camp and canal connecting Sampson Lake to Rowell Lake. Two 25 acre, two 20 acre, and one 10 acre plot were treated to provide access to private homes and to open areas for fishing. One additional 25 acre plot was located adjacent to the public boat ramp on the northern end of the lake.

Plots were located a minimum of 200 feet from littoral vegetation and marked off in five acre increments to facilitate accurate herbicide application. The treatment was conducted during the second week of March, 1983, utilizing both liquid and granular fluridone. The large 75 acre plot and one 25 acre plot were treated utilizing a 45% active liquid formulation at a rate of two quarts per acre. The rest of the plots were treated utilizing a 5% active granular formulation. The entire treatment of 200 acres was completed within a three day period by boat.

Density of individual species of vegetation were estimated in September of 1983 and 1984 as part of the Department of Natural Resources' statewide Aquatic Plant Survey. Additional observations were conducted from March of 1984 until January, 1985, to determine efficacy information for hydrilla and effects of fluridone on non-target species.

III. Results

In April (one month after treatment), symptoms of fluridone activity were observed on new hydrilla growth within all treatment areas with sporadic occurrence of symptoms in untreated portions of the lake. There were no injury symptoms on native species.

Hydrilla began to decline in the plots in May while symptoms of fluridone activity appeared in approximately six inches of new growth in untreated areas. Nitella frequency increased within treated areas and secchi disc readings declined to three feet on the eastern side of the lake as a result of an increase in planktonic algae. Fluridone activity was observed on approximately a .25 acre of cattails on the eastern side of the lake adjacent to the 75 acre liquid formulation plot.

Hydrilla was absent from the treated areas of the lake by June. Fluridone activity was observed on hydrilla in all areas of the lake. Activity of fluridone was observed in the veins of approximately a dozen leaves of fragrant water lily on the southern end of the lake adjacent to a granular formulation plot.

In August, secchi disc readings had returned to the pre-treatment levels of 5-6 feet. Hydrilla was not detected in any portion of the lake either by fathometer readings or by dragging a weed rake. Nitella had become established in many areas where hydrilla had previously been topped-out. Bream beds were also observed in many areas which were overgrown with hydrilla in 1983.

Water levels were three feet lower during September than in March, but the only observable signs of hydrilla were fragments located at the mouth of the canal connecting to Rowell Lake which has a severe hydrilla infestation.

In January, 1985, only floating fragments of hydrilla were observed in Sampson Lake whereas the connecting Rowell Lake was approximately 85% covered.

Table 1 presents acreage estimates for each plant species before the fluridone treatment (1983) and after treatment (1984).

Table 1
Sampson Lake Vegetation

Species	Acreage 1983	Acreage 1984
Hydrilla verticillata	800.0	0.1
Typha spp.	125.0	120.0
Nelumbo lutea	50.0	40.0
Numphaea odorata	35.0	35.0
Fuirena scirpoidea	25.0	25.0
Panicum hemitomon	20.0	20.0
Vallisneria americana	15.0	16.0
Bacopa caroliniana	5.0	5.0
Filamentous algae	5.0	10.0
Paspalidium geminatum	5.0	5.0
Utricularia purpurea	5.0	3.0
Najas guadalupensis	4.0	4.0
Pontederia lanceolata	3.0	3.0
Cephalanthus occidentalis	2.0	2.0
Hydrochloa carolinensis	2.0	2.0
Brachiarai purpurascens	1.0	1.0
Cyperus spp.	1.0	1.0
Eichhornia crassipes	1.0	0.5
Eleocharis spp.	1.0	1.0
Hydrocotyle spp.	1.0	1.0
Juncus spp.	1.0	1.0
Nuphar luteum	1.0	1.0
Alternanthera philoxeroides	0.5	0.5
Lachanthes caroliniana	0.5	0.3
Ludwigia arcuata	0.5	0.5
Nitella spp.	0.5	60.0
Salvinia rotundifolia	0.5	0.1
Total	1110.5	358.0
Percent Plant Coverage	54.5%	17.5%
Percent Hydrilla Coverage	39.2%	0.0
Percent Hydrilla Composition of Plant Community	72.0%	0.0

The only significant changes in vegetation in Sampson Lake were the reduction in hydrilla coverage of 800 acres, the increase in nitella of 59.5 acres, and the increase of filamentous algae of five acres. Minor changes included a five acre decline of cattails (*Typha* spp.) as a result of the fluridone treatment and an illegal cutting operation, and a ten acre decrease in fragrant water lily *(Nymphaea odorata)* from high spring water levels. These data indicate that a large scale fluridone treatment can result in almost complete control of hydrilla while having minimal impact on native vegetation. In Sampson Lake, an increase of submersed native vegetation occurred shortly after the decline of hydrilla.

The total cost of the Sampson Lake treatment program of 200 control acres was $78,615.00 or $393.08 per treated acre. Actual cost of control for the 800 acres of hydrilla was $98.27 per acre for a full year of maintenance control.

In comparison, 40 acres of hydrilla in connecting Rowell Lake were treated in April, 1984, with endothall at a total cost of $7,180.00 or $179.50 per treated acre. Control of hydrilla did not last through the summer, thus an additional application would be required increasing the yearly maintenance cost.

IV. Discussion

With proper planning and execution, fluridone has been effectively utilized to selectively control hydrilla in a large system, while retaining or enhancing existing native vegetation populations. This type of management program is conducive to increased utilization of the water body resulting in tangible economic benefits to residents of the area.

It is important to emphasize that proper timing of herbicide application (in this case March), and location of treatment sites are essential in optimizing hydrilla control while protecting non-target species.

A much more difficult problem to address is the effect on fish populations of removing hydrilla and returning a lake to native vegetation. The only available fisheries information for Sampson Lake is from ten, one acre blocknet samples removed by the GFC between 1974 and 1982. These samples were taken in six different habitats which included: limnetic, maidencane *(Panicum hemitomon)*, American lotus *(Nelumbo lutea)*, maidencane/sparse hydrilla combination, topped-out hydrilla and deep water sparse hydrilla.

This data allows comparisons of total weight of harvestable sportfish for the period before hydrilla domination, during domination and after fluridone treatment. The limited database and duration between samples does not permit precise evaluation, but this information shows general large scale changes which may stimulate some additional research in this area.

To facilitate comparison, the maidencane and American lotus habitat types were combined and Sampson Lake was characterized by five habitat types:

(1) Limentic - open water
(2) Littoral vegetation
(3) Littoral vegetation interface with limnetic habitat (no hydrilla) (assume to make up an 80 foot border six miles long)
(4) Interface of deep water sparse hydrilla with limnetic habitat (assume to make up an 80 foot border five miles long)
(5) Topped-out hydrilla

Weight of harvestable sportfish per acre for each habitat type was computed from appropriate blocknet samples and summarized in Table 2. These values were utilized to estimate the weight of harvestable sportfish for each habitat type and to estimate a total weight of harvestable sportfish for the entire lake during the three listed vegetated time intervals. Values are listed in Table 3.

Table 2
Harvestable Sportfish for Each Habitat

Habitat	Value (lbs./acre)	# of Samples
(1) Limnetic	7.8	2
(2) Littoral vegetation	27.7	2
(3) Littoral vegetation interface with limnetic habitat (no hydrilla)	55.9	3
(4) Interface of deep water sparse hydrilla and limnetic habitat	54.3	1
(5) Topped out hydrilla	11.3	1

These estimates indicate that there was a slight reduction in weight of harvestable sportfish in Sampson Lake as a result of the large scale reduction of hydrilla. However, since the weight of harvestable fish was only 8.5% higher before hydrilla control, it is questionable whether the restrictions imposed on navigation and recreational usage of the lake are worth the additional habitat provided by hydrilla. □

Table 3
Comparison of Harvestable Sportfish in Sampson Lake

	Pre-hydrilla		During Hydrilla Domination		After Fluridone Treatment	
Habitat Type	Acres of Habitat	Harvestable Sportfish (lbs./acre)	Acres of Habitat	Harvestable Sportfish (lbs./acre)	Acres of Habitat	Harvestable Sportfish (lbs./acre)
Limnetic (open water)	1,642	12,808	932	7,270	1,684	13,135
Littoral vegetation	340	9,418	310	8,587	298	8,255
Littoral vegetation interface with lemnetic habitat (no hydrilla)	60	3,354	—	—	60	3,354
Interface of deep water sparse hydrilla with limnetic habitat	—	—	50	2,715	—	—
Topped-out hydrilla	—	—	750	8,475	—	—
Total lbs./acre harvestable sportfish		25,580		27,047		24,744

organisms along with the biological control agent.

Considerable interest and discussion has been generated over use of the grass carp (Figure 1), also commonly called the white amur, for its potential to assist in the management of aquatic weed problems, particularly submersed ones. In fact, the grass carp has caused more controversy than any other biological method ever proposed for the management of aquatic weeds.

Figure 1. A large grass carp grown primarily on hydrilla.

II. Description of Triploid Grass Carp

Grass carp are diploid with a chromosome number of 48. Thus each parent contributes one-half of this number. Triploid grass carp

Management of Hydrilla with Triploid Grass Carp

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I. Introduction

Biological organisms offer unique advantages for management of aquatic weeds which are not available with either chemical or mechanical methods. On the other hand, biological control with some organisms such as phytophagous fish has the potential to create problems extremely difficult to overcome and may result in significant damage to aquatic ecosystems.

Advantages of using efficacious and safe organisms to manage biologically aquatic weeds include (1) longevity of the method once it has become firmly established, (2) constant pressure against the problem weed, (3) minimal impact on non-target organisms, (4) low costs, (5) highly effective, and (6) the potential for conversion of the weed to a useful product.

Disadvantages of biological methods may include (1) difficulty in regulating the numbers of the organism, (2) lack of adequate distribution of individual organisms to the target weed, (3) replacement of the primary weed problem with secondary aquatic weed species, (4) significant impact on non-target aquatic plants once the weed population has diminished, and (5) distribution of unwanted parasitic are fish which have been produced from diploid parents. The triploid fish however contain an extra set of chromosomes for a total of 72 which, as far as is presently known, makes them sterile or incapable of spawning viable offspring. However, other naturally occurring populations of triploid fish which reproduce by gynogenesis are known to exist.

The mechanism which results in the production of triploid grass carp from diploid parents is not clearly understood, but may involve the retention of a polar body by the ovum similar to that which occurs in other triploids.

The procedure for producing triploid grass carp is to subject fertilized eggs from diploid parents to a heat shock which causes the eggs to retain an extra set of chromosomes for a total of 72. Heat shock has been found to induce triploidy in other fishes. Furthermore, a cold shock of the eggs will also result in triploid fish.

Triploid grass carp have visible external characteristics that are about the same as normal diploid fish. However, because of the extra set of chromosomes, the blood nucleus is large, and its size can be measured with an instrument such as the Coulter Counter to distinguish the triploid fish from diploid ones. In this way each fish can be screened in order to ensure that it is a triploid.

Feeding behavior and other characteristics of the triploid grass carp appear to be almost identical to that of diploid fish. Therefore, it is assumed that essentially all the information which has been obtained from studies with diploid grass carp can be transferred directly to the triploid fish. If there are differences, they will likely be small and probably not make the feeding habits much different.

Because the triploid fish are sterile and do not make large numbers of gamates, their feeding behavior may be somewhat different than diploid fish as they age. Energy requirements may differ between these two fish because the triploid ones will probably require less energy for development of reproductive organs.

For example, it is well known that both mature female and male diploid grass carp develop eggs and sperm whether they spawn or not. In Florida since no known natural reproduction of the grass carp has occurred, the females apparently reabsorb their large egg masses each year. Feeding behavior of the female fish during this time is not known, but is probably low due to the large amount of energy in the eggs which must be dissipated by the fish.

III. Characteristics of Hydrilla which Make it Suitable for Management by Triploid Grass Carp

Hydrilla has several characteristics which make it suitable for management by triploid grass carp. First, hydrilla is high on the list of plants preferred by the grass carp, and it grows rapidly on a diet of this weed.

An interesting feature of hydrilla is the development of long internodes when the plant is in deep water. Once the plant reaches the surface the internodes shorten and it begins to branch profusely. Since the grass carp prefer to feed near the surface, they eat the shoots of hydrilla as the plant grows in the water column towards the surface.

The manner in which grass carp feed on these towering strands of hydrilla is an important consideration, especially with low stocking rates of fish. When a few grass carp are present, they feed on hydrilla near the surface. Since the hydrilla is prevented from forming the dense mat of plants which reduces light penetration to the sediment, it then becomes possible to have plants, such as Chara and others which do not fill the water column, growing below the surface, while the grass carp continually eats any new hydrilla regrowth trying to reach the surface.

And finally, new growth from sprouting of hydrilla tubers and turions supplies food, although in small quantities, for several years after the grass carp are stocked.

IV. Management Techniques

1. Size of Grass Carp to be Stocked

Small grass carp have a number of enemies such as birds, snakes, and other fish. Fish that are at least 12 inches in length or about a pound in weight are the minimal size which should be stocked for good survival. Mortality rate increases with fish smaller than this.

Small grass carp will have a better chance of survival if they are stocked when the weeds are dense enough to provide protective cover. When the weed biomass is low, such as after a herbicide treatment or in a new body of water, fish in good condition and weighing 1.0 pound or more will survive better than smaller fish.

2. Use of Grass Carp Alone

Removal of hydrilla with grass carp alone is dependent on stocking fish in sufficient numbers so that their consumption rate exceeds the growth rate of the hydrilla. Rates of 20 to 255 grass carp per acre have been found to provide effective control of hydrilla.

Since there are so many factors which influence the control of hydrilla by grass carp, it is difficult to give specific stocking rates for every situation. Dense amounts of hydrilla will obviously require more fish than sparse growth.

A good rule of thumb is to stock 20 to 30 fish per acre, and then a year to a year and a half later add more fish if the desired level of control has not been achieved.[1]

The number of acres of weed infested area in relation to the number of total areas needs to be taken into consideration when determining the number of fish to stock. Transect lines, a recording fathometer, biomass sampler, or aerial surveys can be used to help estimate the amount of weeds present. In this way, the fish can be stocked according to the amount of vegetation, and not the total area of the body of water under consideration.

Severe low oxygen levels can be encountered in small bodies of water with a dense growth of hydrilla. In this case, it is better to use herbicides or to mechanically remove the hydrilla before stocking the fish. A few measurements of dissolved oxygen made just prior to sunrise would be a good investment of time when a questionable situation arises. Dissolved oxygen readings of at least 3.0 ppm would help ensure good survival of the fish.

3. Use of Herbicides plus Grass Carp

Use of herbicide to remove a majority of the biomass of hydrilla followed by stocking with grass carp would reduce the number of fish required, since the fish would need to consume only the newly emerging growth of hydrilla. For example, 5 grass carp per acre in small bodies of water have been found to provide control of

[1]Stocking rates or suggestions for use of triploid grass carp are not an endorsement by the University of Florida but rather they represent the opinion of the author. Successful control of hydrilla depends on many factors. Therefore, this article is for informational purposes only and is not intended to provide an endorsement of a product or method to the exclusion of other products available for control of hydrilla.

hydrilla regrowth following use of herbicides. Rates even lower than this may result in effective weed control since this rate of 5 fish per acre in some situations was found to completely eliminate all submersed plant growth. Therefore, in order to prevent regrowth of hydrilla but at the same time allow for growth of other desirable submersed plants, rates of 1 to 3 fish per acre may be suitable with an occasional spot treatment of herbicide to control any new growth of hydrilla which becomes more abundant than the fish can eat.

When herbicides are used, sufficient time must be allowed for the effects of the herbicide to diminish prior to stocking of triploid grass carp. Water with low dissolved oxygen due to decaying vegetation may be unsuitable for good survival of fish. A few oxygen measurements will give a good indication as to whether or not the water quality is suitable for stocking of the triploid grass carp.

Triploid grass carp which weigh at least 5 pounds will provide better results than small fish when stocked after application of herbicides. Predation will be less on these large fish, and if they are in good condition prior to stocking, they should be able to survive on minimal amounts of vegetation for several years.

Large triploid grass carp will be difficult to obtain commerically. Therefore, an aquatic weed manager will either have to culture small fish to a large size or recapture them from areas where they have eliminated the weed problems in order to have large fish available for use.

4. Time of Year for Stocking Triploid Grass Carp

The time of year to stock triploid grass carp will depend primarily on the availability of fish and water quality. When the fish are used in conjunction with herbicides, stocking needs to be prior to regrowth of hydrilla but after the effects of the herbicide have dissipated.

The fish can be transported and handled much easier during the cooler months of the year than during the hot summer months. Injured fish will not be as susceptible to diseases when stocked in cool water as opposed to warm water. Also, cool water contains more dissolved oxygen than warm water.

5. Use of Other Methods plus Triploid Grass Carp

Because of the restrictions placed on the use of diploid grass carp, limited work has been done on the use of this fish in conjunction with other methods such as mechanical control prior to stocking of these herbivorous fish. However, a rate higher than that required with herbicides, but lower than with fish alone would be required following mechanical removal of hydrilla.

Mechanical methods may be especially useful for removing portions of dense mats of hydrilla. This will create areas free of the plants where the fish might not be subjected to low oxygen levels. Also, triploid grass carp may be particularly effective in consuming the fragments of hydrilla which are generated with mechanical harvesting.

Dr. John Osborne of the University of Central Florida has obtained good control of hydrilla after first using a sampler to estimate the biomass of hydrilla and then stocking grass carp according to the abundance of plants present. A biomass sampler will be useful to assess the number of triploid grass carp required for a given body of water, once the feeding rate of this fish is known.

One area of study which will be of interest is to use the triploid grass carp to manage hydrilla concomitant with establishment of other desirable, native aquatic plants. In order to accomplish this, low numbers of fish or plants low on the list of foods preferred by the fish will be important considerations. With triploid grass carp, it may be possible to eliminate hydrilla in many bodies of water and promote growth of desirable aquatic plants to enhance water quality.

V. General Considerations for Managing Hydrilla with Triploid Grass Carp

Grass carp have been found to provide effective biological control of hydrilla in a variety of types of water bodies. The key to successful control of hydrilla with the grass carp is a combination of sufficient numbers of fish confined to the target area and water with sufficient dissolved oxygen.

The lethal point for grass carp is about 0.5 ppm of dissolved oxygen. However, dense growth of hydrilla can result in oxygen levels below this amount which will suffocate them. Therefore, the

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Efficiency and Cost of Aquatic Weed Control in Small Ponds

Jerome V. Shireman, Douglas E. Colle and Daniel E. Canfield Jr.
Department of Fisheries and Aquaculture
Center for Aquatic Weeds
University of Florida
Gainesville, Florida 32611

Aquatic weed infestations are a common problem in small ponds throughout the United States. Prior to managing a specific aquatic weed problem, the user group generally attempts to obtain information on the environmental impact, efficiency, and cost of different aquatic plant management techniques. Information on the environmental changes that may occur is generally available, but there is very little information on the efficiency and costs of different plant control techniques. In this paper, we compare the long-term efficiency and costs of managing aquatic vegetation in 20 small ponds at Welaka, Florida, and at different control levels with three commonly used management techniques: herbicides, grass carp *(Ctenopharyngodon idella)*, and a combination of fertilizers and mechanical harvesting.

Fertilization and mechanical harvesting were the most expensive aquatic macrophyte management techniques (Table 1). Fertilization costs were $246/acre/year and mechanical harvesting costs were $801/acre/year or a total treatment cost of $1,047/acre/year. The U.S. Army Corps of Engineers spent $495/acre to mechanically harvest 163 acres of hydrilla in Orange Lake, Florida for a four month period in 1977 (McGehee 1979). Sassic (1982) estimated mechanical harvesting costs at $75.09/acre/harvest based on data from the East County Water Control District, Lee County, Florida. Both authors felt that although mechanical harvesting costs were high, they were comparable to herbicide treatment costs. Submersed vegetation in our mechanically harvested Welaka ponds reached 100% pond volume occupation levels in approximately one month and McGehee (1979) reported that Orange Lake boat trails required cutting every 15 to 56 days. Total costs for mechanically harvesting ponds will, therefore, depend on the number of treatments needed, but on the average costs of over $405/acre/year are probably realistic.

Herbicide treatment costs were dependent upon the level of vegetation management and ranged from $169 to $542/acre/year (Table 1). Sassic (1982) stated that herbicide treatment costs in 1982 within the state of Florida ranged from $150.00 to $300.00/acre/treatment. If control rather than elimination of submersed vegetation is the management goal, aquatic herbicides are much more cost effective than fertilization and/or mechanical harvesting (Table 1). Herbicide control costs were 50% lower for treatment in which submersed vegetation was allowed to occupy at least 40% of the pond volume.

Grass carp management costs ranged from $64 to $100/acre/year. Cost differentials were caused by different stocking rates. Osborne (1982) estimated that the average cost of using grass carp to eliminate hydrilla within one year

Table 1. Average vegetation control costs per acre per year based on four years (1979) to 1983) of management for a predetermined volume of aquatic vegetation and harvestable fish biomass at termination in ponds at Welaka, Florida.

Treatment	Volume	Cost (U.S. $)	Harvestable Centrarchids		
			Cost/Fish	Biomass (lbs.)	
				Bluegill	Large mouth bass
Fertilization and mechanical[1] harvest	0	1047(801)[a]	11.52	54	100
Grass carp	70	64	0.58	85	30
	40	88	0.72	95	29
	0	100	0.93	84	39
Herbicide	70	169	4.77	27	33
	40	219	2.89	62	44
	0	542	11.20	37	63
Control	100			28	21

[a]Value in parenthesis is a mechanical harvesting cost.

was $125.43/acre based on data from four lakes in Florida. Shireman (1982) reported initial costs of $8,499 for a 198 acre Florida lake. Vegetation has now been controlled for seven years or for a cost of $6.13/acre/year. Experiments in Egyptian irrigation canals indicate that weed control with grass carp costs half that of conventional methods (van Zon 1984). In addition, the value of fish yields (grass carp) in these systems exceeds weed control costs; thus making weed control profitable. Although grass carp costs were reported as an actual per year cost for our study, long term costs would be proportionally lower because vegetation control would have been effective for a minimum of four additional years without subsequent stockings. The other management techniques, herbicides and fertilization and mechanical harvesting, are annual costs. Cost reductions for the non-grass carp techniques can occur only when labor and/or material prices are reduced.

Another way of evaluating the relative cost of different aquatic plant management techniques is to express the costs in terms of a desirable end product such as harvestable fish. The actual cost incurred during our study per harvestable centrarchid (bluegill 6 inches TL (Total Length), largemouth bass 10 inches TL, was calculated for each control method (Table 1). Cost values were calculated by dividing vegetation control costs for the entire study into the total number of harvestable fish recovered at project termination. Expenditure per harvestable fish varied from $11.52 for fertilization and mechanical harvesting to $0.58 for the lower grass carp stocking densities. Attempting to provide complete vegetation control with herbicides resulted in costs equivalent to fertilization and mechanical harvesting ($11.20/harvestable fish). Utilization of grass carp for submersed vegetation control was the most cost-effective management plan examined. However, the most inexpensive fish production did occur within the two control ponds. Harvestable fish production was 233 fish/acre in pond 1 and 89 fish/acre in pond 16, but these ponds were subject to periodic oxygen depletions because of the excessive growth of aquatic plants. When oxygen levels are depleted major fish kills can occur.

Before a vegetation management technique is selected, management priorities should be established. Although different techniques were used in this study, comparable biomass of harvestable fish was produced for different levels of vegetation control (Table 1). The control ponds produced harvestable fish, however, these fish may have been inaccessible to the sport fisherman due to complete vegetation coverage. The potential also exists for fish kills due to oxygen depletion. Major environmental changes are generally related to the amount of vegetation controlled rather than to the control method. Cost of weed control should, therefore, be a major consideration in selecting control methods, especially when monetary resources are limited. Grass carp can provide a long-term, cost-effective management method for submersed vegetation in small ponds and most likely for many larger aquatic systems. Grass carp should be given greater consideration as an aquatic plant management technique.

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van Zon, J. C. J. 1984. Economic weed control with grass carp. Tropical Pest Management. 30(2):179-185. □

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amount of dissolved oxygen in the water is an important consideration when these fish are stocked.

In bodies of water which have culverts or canals leading to other areas, screens or gates must be installed to prevent escape of the triploid grass carp. Barriers will need to be constructed such that the fish cannot jump over them, if the triploid fish prove to be as strong and active as the diploid ones.

When grass carp are used alone, removal of non-target plant species may occur after the hydrilla is removed. Many more fish are available than the number required to prevent regrowth of the hydrilla. A combination of low numbers of fish and judicious use of herbicides is a good approach to consider, in order to attempt to obtain a balanced situation.

It is much easier to add triploid grass carp than to remove them from a body of water. About the only known method for complete removal of grass carp is to use a fish toxicant such as rotenone. In treating a body of water with rotenone, grass carp come to the surface where they can be captured for movement to another body of water. However, use of rotenone will almost always result in mortality of native game fish unless they too are captured and moved since many of them are very sensisive to this chemical.

To remove grass carp alive from a body of water treat with about 0.1 ppm of rotenone. After application of this chemical, the fish will swim to the surface in an effort to 'gulp air'. They can then be caught with nets, placed in fresh, aerated water, and revived. Potassium permanganate added to the water in sufficient amounts to result in a solution of 0.1 ppm will help revive the fish. In capturing large fish, the rotenone will have a tranquilizing effect on them, and make them easy to handle. Diploid grass carp captured by this method appear to suffer little, if any, ill effects. In this way it is possible to move fish from one area to another to effectively utilize them for different stocking situations.

Finally, there are some areas which probably should not be stocked with these with herbivorous fish. For example, stocking in rivers such as Crystal River, and bodies of water such as Lake Okeechobee where the fish cannot be confined to the target areas will probably result in little noticeable control of the hydrilla growth.

6. Permit Requirements

Triploid grass carp may be used for aquatic weed control in Florida after a permit is obtained from the Florida Game and Freshwater Fish Commission (FGFFC). An application for a permit may be obtained from Mr. Clayton L. Phillippy, Bureau of Fisheries Management, FGFFC, 620 S. Meridan St., Tallahassee, FL 32301; and from the FGFFC Regional Biologists.

VI. Summary

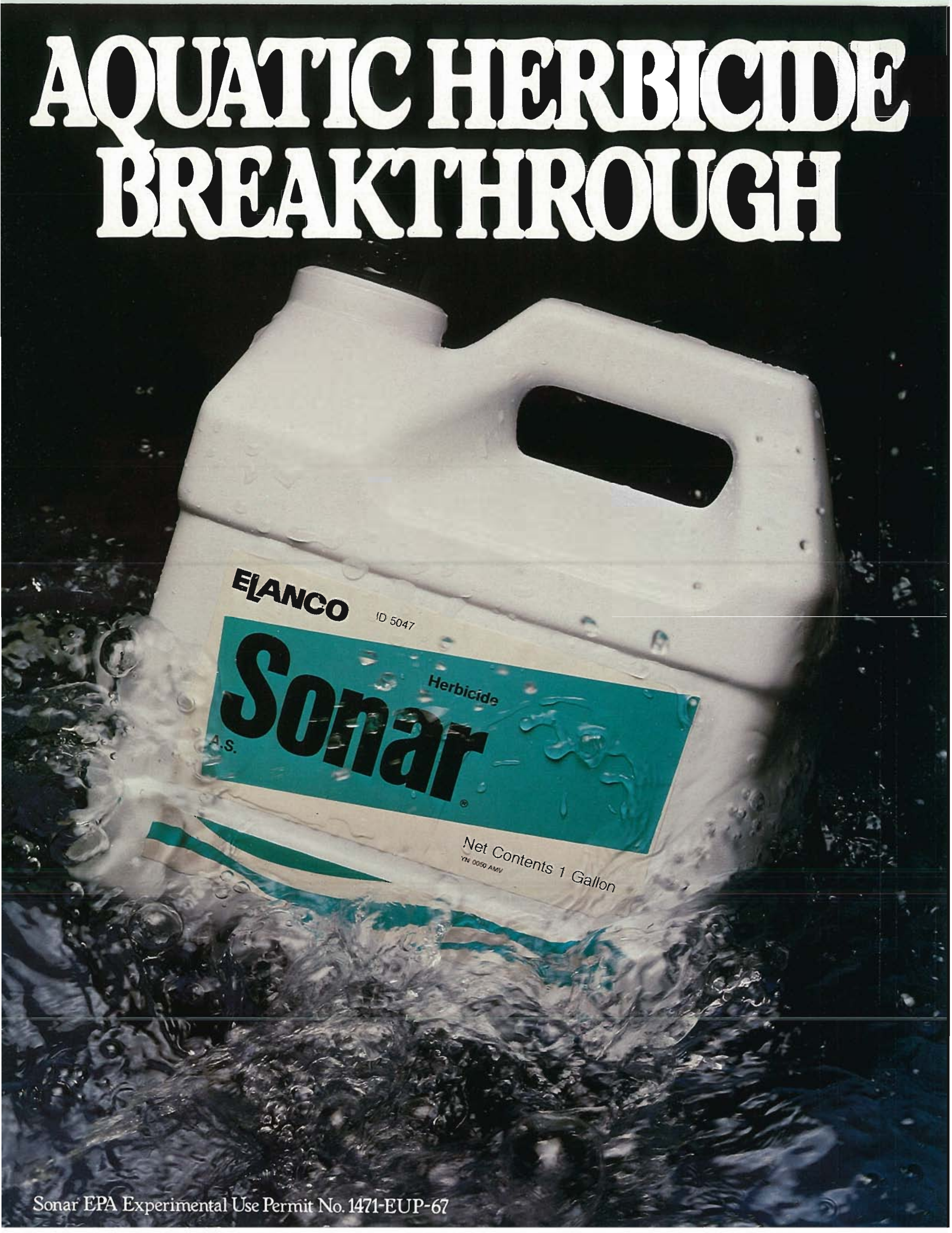
If the feeding behavior of the triploid grass carp is similar to that of its diploid parent, then it will be possible to eliminate hydrilla in many bodies of water. A management program consisting of low stocking rates of triploid fish and periodic applications of herbicides may be the best way to reduce nuisance growth of hydrilla and at the same time encourage growth of desirable native aquatic plants. Also, if the triploid fish are as efficient as the diploids in utilizing aquatic plants, then an additional benefit of converting unwanted weeds to a valuable fish protein source will be realized.

VII. Literature Cited

In order to conserve space in the *Aquatics* magazine, citations for published information used in the preparation of this article are not presented. A list of references, as well as the scientific names of fish and plants, used in the preparation of the text may be obtained from the author.

VIII. Acknowledgments

I wish to thank Dr. W. B. Ennis, Jr., Dr. Ted Center, Mr. Jess Van Dyke, Mr. Rue Hestand, and Mr. Clayton Phillippy for their critical review of this article. Also, I express my appreciation to Dr. Jon Stanley for his valuable comments and suggestions for improvement of some of the concepts developed. □


AQUATIC HERBICIDE BREAKTHROUGH
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Sonar®
gently puts the balance back in nature.

At last there's a new generation aquatic herbicide that manages a host of undesirable vascular plants without mismanaging the good life. Sonar® from Elanco.

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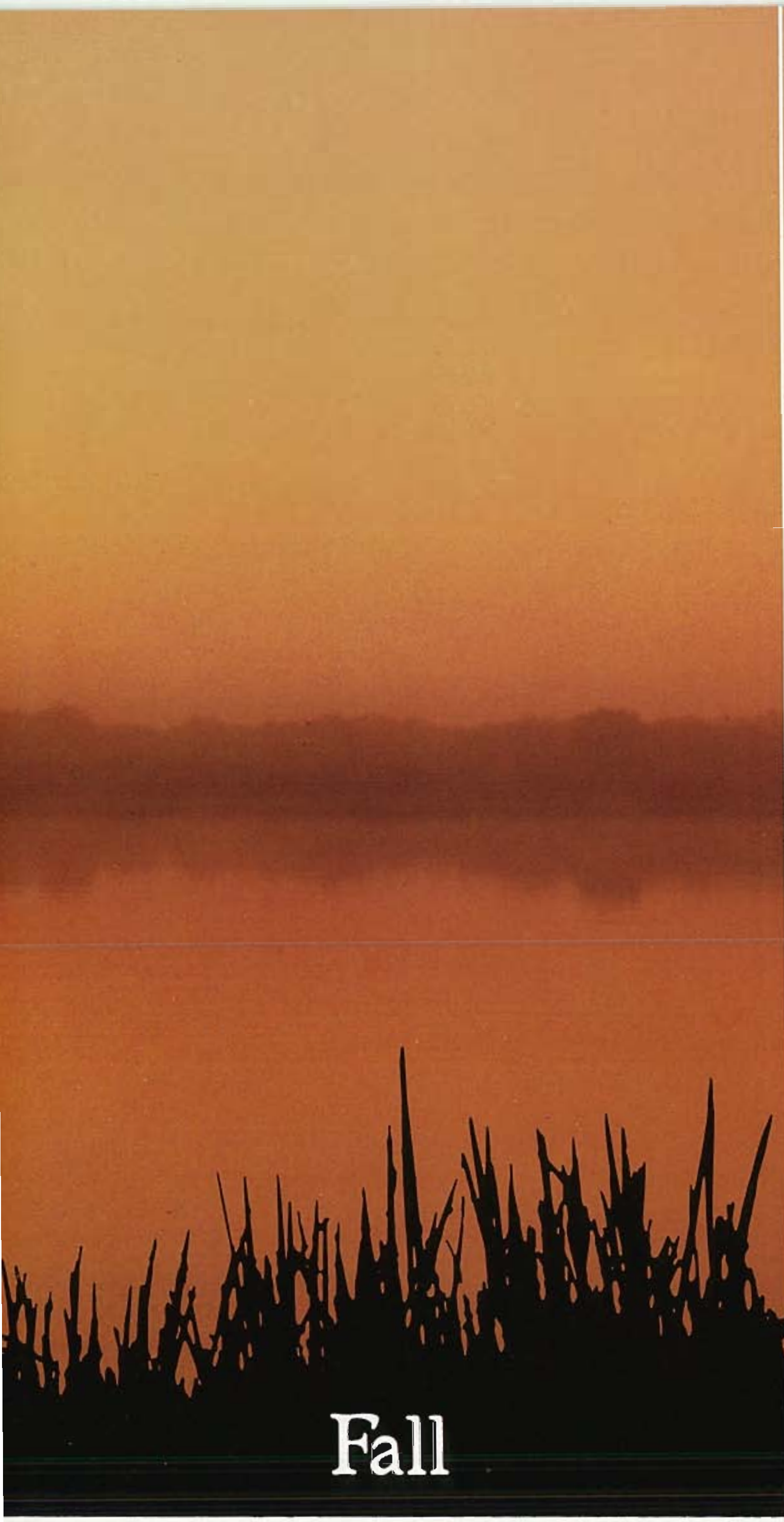
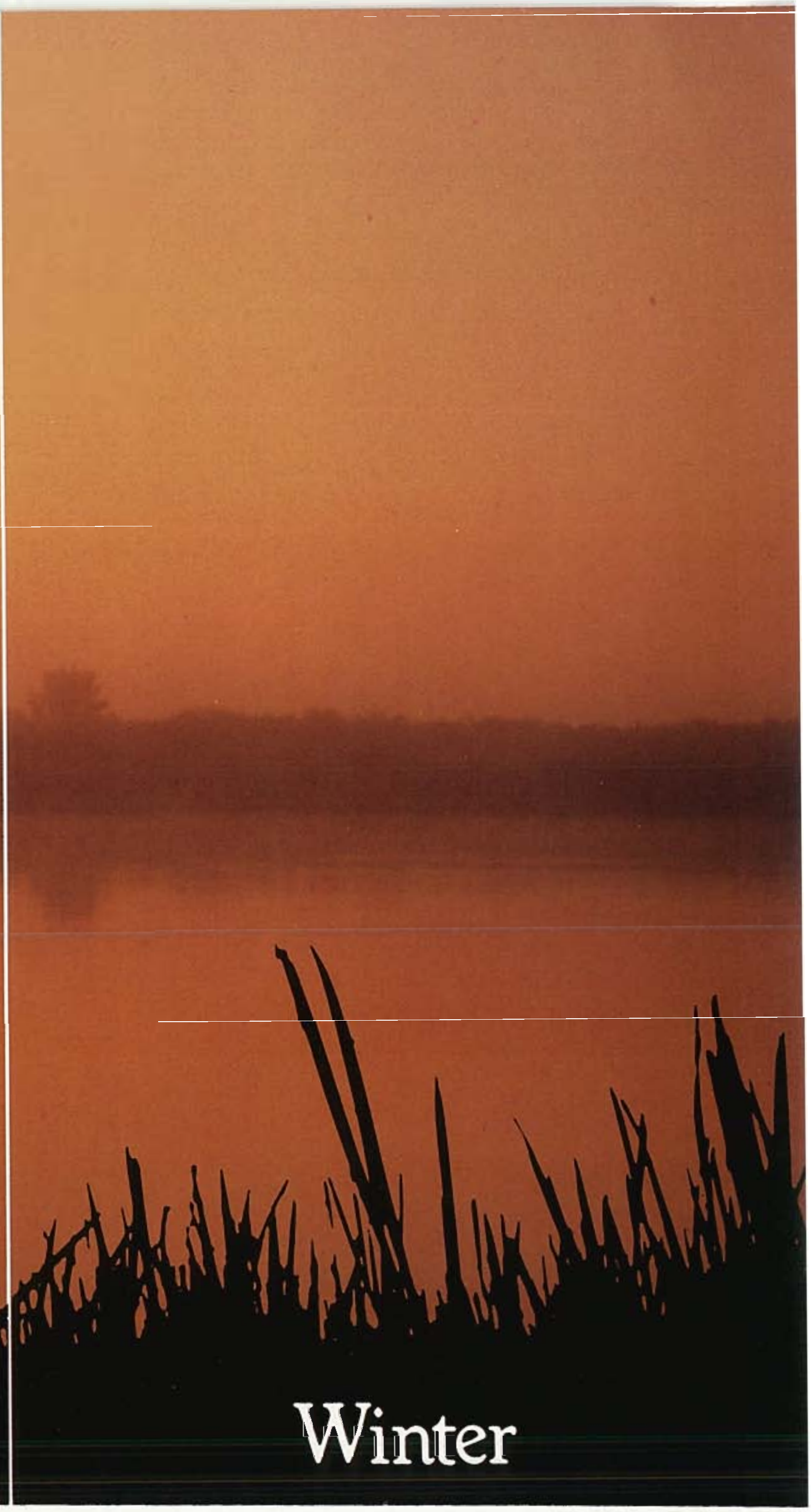
Four to six weeks after treatment, Sonar takes its toll on undesirable vegetation. And because of its slow action, there is no rapid oxygen depletion. This makes Sonar highly compatible with the aquatic environment and makes fish kills a thing of the past. Applied as directed, Sonar will not harm fish,


Hydrilla


Elodea


Water milfoil





wildlife, or nearby trees and shrubs.

Flexible application.

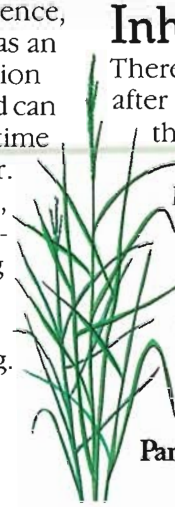
Sonar can be applied to the entire surface of a pond or up to ten percent of larger bodies of water. Depending on existing equipment and user preference, Sonar is available as an aqueous suspension or 5% pellet and can be applied any time during the year. For best results, the label recommends applying Sonar when weeds are actively growing.

Pond weeds

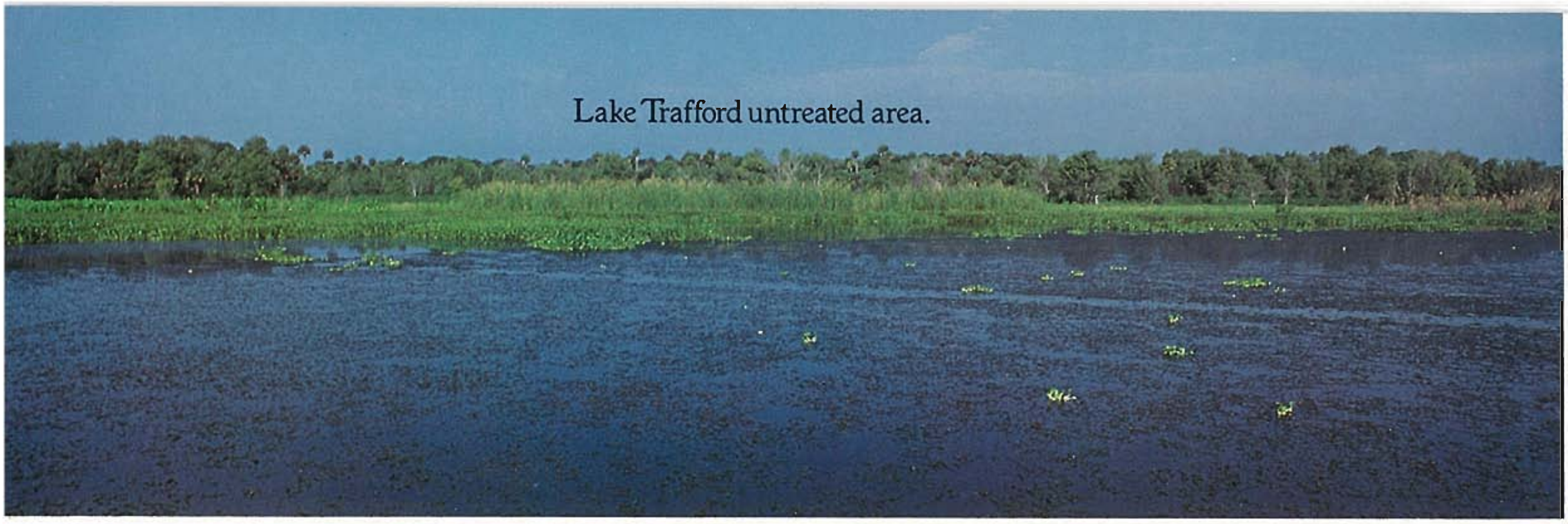
Torpedograss

Inherent value.

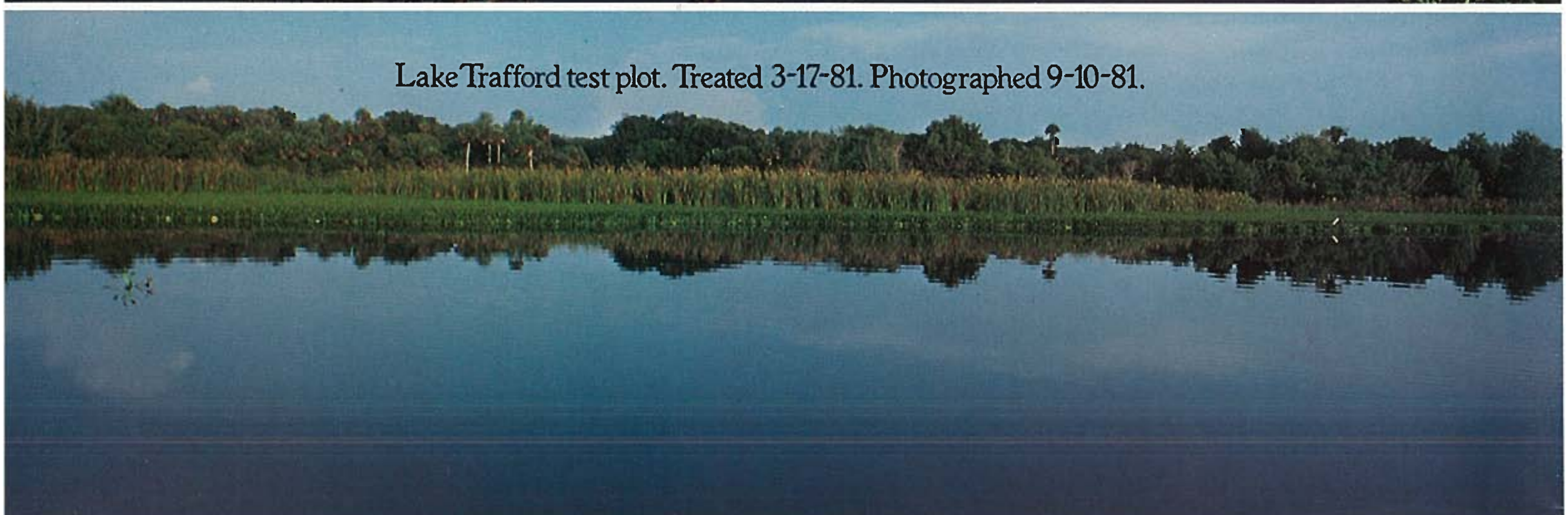
There are few restrictions after application, and they are detailed on the product label. Make Sonar part of your management program. It's the simple, gentle way to put nature back in balance.



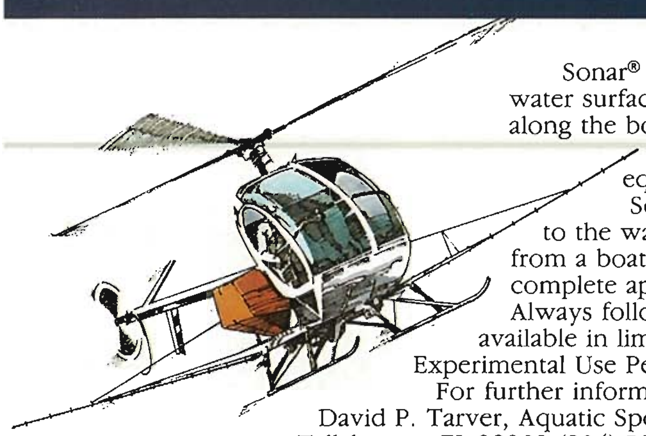
Paragrass



Lake Trafford untreated area.



Lake Trafford test plot. Treated 3-17-81. Photographed 9-10-81.



Sonar® aqueous suspension can be applied to the water surface or under the water surface or placed along the bottom of the water just above the hydrosoil. Any conventional application equipment can be used.

Sonar 5% pellet can be applied to the water surface from the shore or from a boat. Refer to the Sonar label for complete application instructions.

Always follow label directions. Sonar is available in limited quantities under EPA Experimental Use Permit No. 1471-EUP-67.

For further information write or phone:
David P. Tarver, Aquatic Specialist, 2416 McWest Street,
Tallahassee, FL 32303 (904) 562-1870

AQUA-VINE

NEW CHIEF

As of May 1, 1985, the Department of Natural Resources has an interim replacement for Danny Riley as Bureau Chief in the Bureau of Aquatic Plant Research and Control. Jack Woodard has temporarily replaced Danny until a decision is made for a permanent successor. Jack has been with the Department for 22 years, most of which was spent with the Division of Resource Management's State Lands. Jack's experience with aquatic plants has come from his working association with previous Bureau Chiefs and his involvement with the now defunct Canal Authority. Danny has left the Department in order to continue his education in pursuit of a medical degree from the University of Florida. We certainly wish Danny the best of luck.

APMS

The 25th Annual Meeting of The Aquatic Plant Management Society will be held in Vancouver, British Columbia, Canada, on July 21-24, 1985. For more information contact Bill Rushing, P.O. Box 16, Vicksburg, Mississippi, 39180.

BOOTH SPACE

If you plan on presenting a display at the Oct. 15-17 FAPMS meeting in Plant City this year, you need to contact Larry Maddox to reserve booth space. Larry can be reached at 2133 N. Wickham Rd., Melbourne, FL 32935-8109, (305) 254-1761.

SCHOLARSHIP

Criteria are being established for the selection of a recipient of the first William L. Maier and Florida Aquatic Plant Management Society Memorial Scholarship. If all goes as planned, an award will be presented at the October meeting this year.

CALL FOR PAPERS

October will be here before you know it! If you plan on presenting a paper, get your request in to Bob Arnold, Program Chairman, 231 Stevenage Dr., Longwood, FL 32750, as soon as possible.

APPLICATOR OF THE YEAR AWARD SOLICITATION FOR NOMINATIONS

The "Applicator of the Year" award will again be presented to the most deserving applicator or spray crew at the F.A.P.M.S. annual meeting in Plant City. Plaques will be awarded to express the society's appreciation for a job well done. Honoring the applicators, who exemplify what our society stands for on a daily basis, is an important task which warrants participation by all society members.

Since many deserving applicators are out there, the awards committee would like to receive as many letters of nomination as possible. This request is being made well in advance of the October meeting to enable society members who are aware of deserving applicators to submit nominations. Nominations will be accepted from federal, state, local or private agencies and do not have to be submitted by supervisory personnel.

The selection committee will consider the following questions when reviewing nominations:

1. Has the nominee avoided unnecessary complaints from home owners, etc. with respect to weed control operations?
2. Has the nominee received any compliments or special recognition from home owners or other persons with respect to weed control operations?
3. Has the nominee successfully worked in any particularly sensitive areas, i.e., environmental, political, etc.?
4. Does the nominee have good public relations abilities, i.e., able to explain to concerned citizens the importance and safety of aquatic plant control operations?
5. Is the nominee experienced in aquatic plant management or related fields?
6. Does the nominee have a broad knowledge of aquatic plant management, i.e., plant identification, available control methods, and regulations?
7. Does the nominee maintain equipment and possess innovative ability to improve or modify equipment or techniques?
8. Is the nominee enthusiastic about aquatic plant management and express interest in keeping abreast of current advancements by attending training courses when given the chance?
9. Any additional information about the nominee which makes them deserving of the Applicator of the Year Award.

The deadline for receiving nominations shall be October 2, 1985. Please send all nominations to:

Brian Nelson
1849 Meriadoc Road
Tallahassee, Florida 32303 □

Applicator's Corner
ask the
"WEED DOCTOR"

Question:

What, if anything, can be used to get some relief from slender spikerush?

Answer:

C. E. Timmer, Vice President-Botanist, Florida Aquatic.

Slender spikerush or needlerush *(Eleocharis baldwinii)* belongs to the Cyperaceae or sedge family. With over 20 species found in Florida, *E. baldwinii* is the most prevalent. Its growth habits are varied. It grows in shallow water, in deep water, or in mats on the surface. Spikerush also grows as a pure terrestrial in moist soil. It does not compete well with other submersed weeds and only became a problem as shorelines were cleared of other vegetation.

Much of our current research centers on this most difficult-to-control plant.

Endothal and Diquat at maxi-

con't. on back cover

Clean up . . . with a clear conscience.

Pennwalt's aquatic herbicides: The responsible choice for aquatic weed control.

For 25 years, Pennwalt's aquatic herbicides have been effectively controlling aquatic weeds without harming the aquatic environment. Based on endothall, these products disappear rapidly from the water and soil through microbial degradation.

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They do not bioaccumulate in the food chain, nor do they bind or leave residues in the hydrosoil. And Pennwalt's aquatic herbicides provide an ample safety margin to fish, shellfish, birds, and other wildlife.

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Aquathol® K Aquatic Herbicide
Aquathol® Granular Aquatic Herbicide
Hydrothol® 191 Aquatic Algicide and Herbicide
Hydrothol® 191 Granular Aquatic Algicide and Herbicide

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mum label rates burn the leaves, but offer no permanent control. 2,4-D offers temporary results, and must be reapplied every 3rd or 4th week to achieve control. Aquazine is ineffective. Sonar liquid and granules at maximum rate can be effective in contained lakes or ponds, but not as a marginal treatment, which is the typical growth situation of slender spikerush.

A pre-treatment drawdown increases effectiveness of many herbicides. Fenatrol and Sonar are particularly effective in this manner. Casoron G-10 is effective and consistent at maximum rate, even when applied on a marginal basis. However, restrictions on the Casoron label are a serious limitation at this time. UniRoyal is currently researching Casoron's aquatic potential.

We hope slender spikerush is not one of your problems.

Answer:
Joseph B. Frost, Branch Manager, Joyce Environmental Consultants, Inc.

Over the years we have evaluated several aquatic herbicides and application techniques to control this species. The first and possibly the most effective, is the application of Hydrothol 191 granules. Best results are obtained by band or block application at relatively high rates. Application rates of approximately 3.0 ppm (160 lbs./acre), has provided 75% to 100% control. Water depth and flow will influence control.

The second control method for spikerush is the application of Diquat and Cutrine Plus (copper). This herbicide combination is applied at surface acre rates of two (2) gallons and four (4) gallons respectively. Application should be made in band or block treatments, similar to that of Hydrothol 191. Water flow will also influence the effectiveness of this treatment.

Answer:
Ed Miller, President-Biologist, Southern Weed Control Management, Inc.

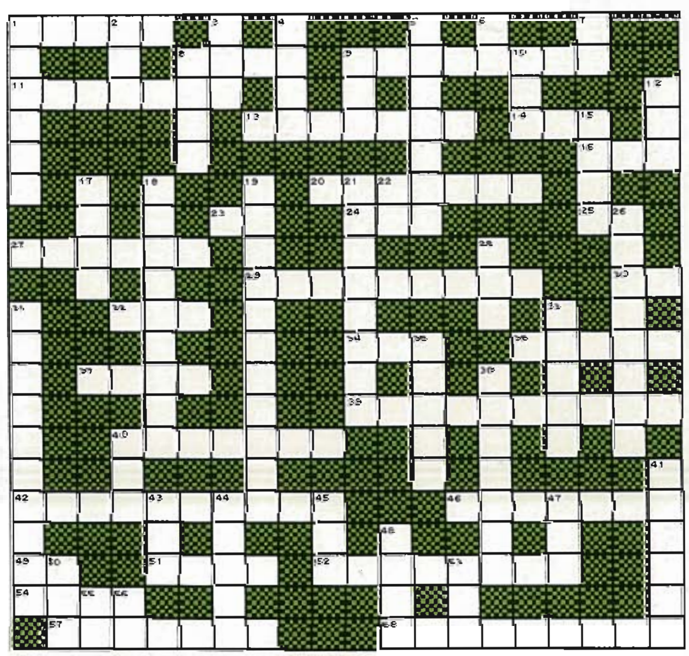
Jeff Mangel, Aquatic Biologist out of our West Palm office, has found that a combination of LV4 at maximum label rate + powdered talc at 4 lbs./50 gal. water + polymer, has proved to be an effective treatment. Rodeo + a citrus blended oil at maximum label rate can provide season long ditch bank control or when low water exposes vegetation. Diquat at 2 gal./acre + $CuSO_4$ at 3.0 ppm will give rapid results when a quick burn is desirable. Aqua-kleen at maximum label can give adequate results.

Answer:
Paul C. Myers, President-Biologist, Applied Aquatic Management, Inc., and Joe Hinkle, Biological Scientist III, Department of Natural Resources.

Both noted that spikerush was not a major concern in the predominantly North Florida area where they work. However, when a spikerush problem does appear, both indicated that a total pond treatment with the maximum label rate of Sonar has given them season long control where it has been employed. □

ACROSS CLUES

1. First editor of AQUATICS
8. 2.2 lbs. in metric
9. Water lowering
11. By-laws committee chairman
13. North flowing river in Florida
14. The meeting of opposing tides
16. Sun beam
20. 2,4-dichloro' 'acetic acid
23. Active ingredient (abbr.)
24. Affirmative reply
25. Acidity of water
27. Oil and water mix
29. Popular "Wild Bill" phrase
30. Dissolved oxygen (abbr.)
32. First FAPMS president
34. A rule of conduct
36. 'B' is the chemical symbol for ' '.
37. The next FAPMS meeting will be held in Plant ' '.
39. Measures wind speed
40. Regulates droplet size
42. Certified '
46. Sex of hydrilla plants in Florida
49. Emulsifiable Concentrate (abbr.)
51. Alligator embryos
52. Sterile grass carp
54. Floating island
57. Drift retardant
58. 39,000-acre lake in south central Florida



DOWN CLUES

1. Sensitive plant, ' ' pigra.
2. Female sheep
3. To join
4. Bottom acre ' '
5. A cause of dark water
6. Identification (abbr.)
7. Not off, but ' '.
8. Ocean algae
9. A typical air-boat crew
10. Paddle
12. Portion of large water body
15. Propels an air-boat
17. Number of Water Management Districts
18. Mechanical ' '
19. Water scientist
21. Florida elodea
22. Environmental engineer (abbr.)
26. pH measures concentration of ' ' ions
28. ' ' grass
31. River of grass
33. Aquatic Roundup
35. Unwanted aquatic plants
38. ' 'grass
40. Petroleum
41. 'Great ________' with Steve McQueen
43. Water at 30 degrees (F.)
44. Single celled green organisms
45. Plant decomposition
47. First ' '
48. Cide-' '
50. 16th of a gallon
53. Pounds (abbr.)
55. Carry out
56. Deciliter (abbr.)

The first person (with the exception of J. C. Joyce and W. T. Haller) to send the editor a correctly completed puzzle, will get their membership dues for 1986 free.