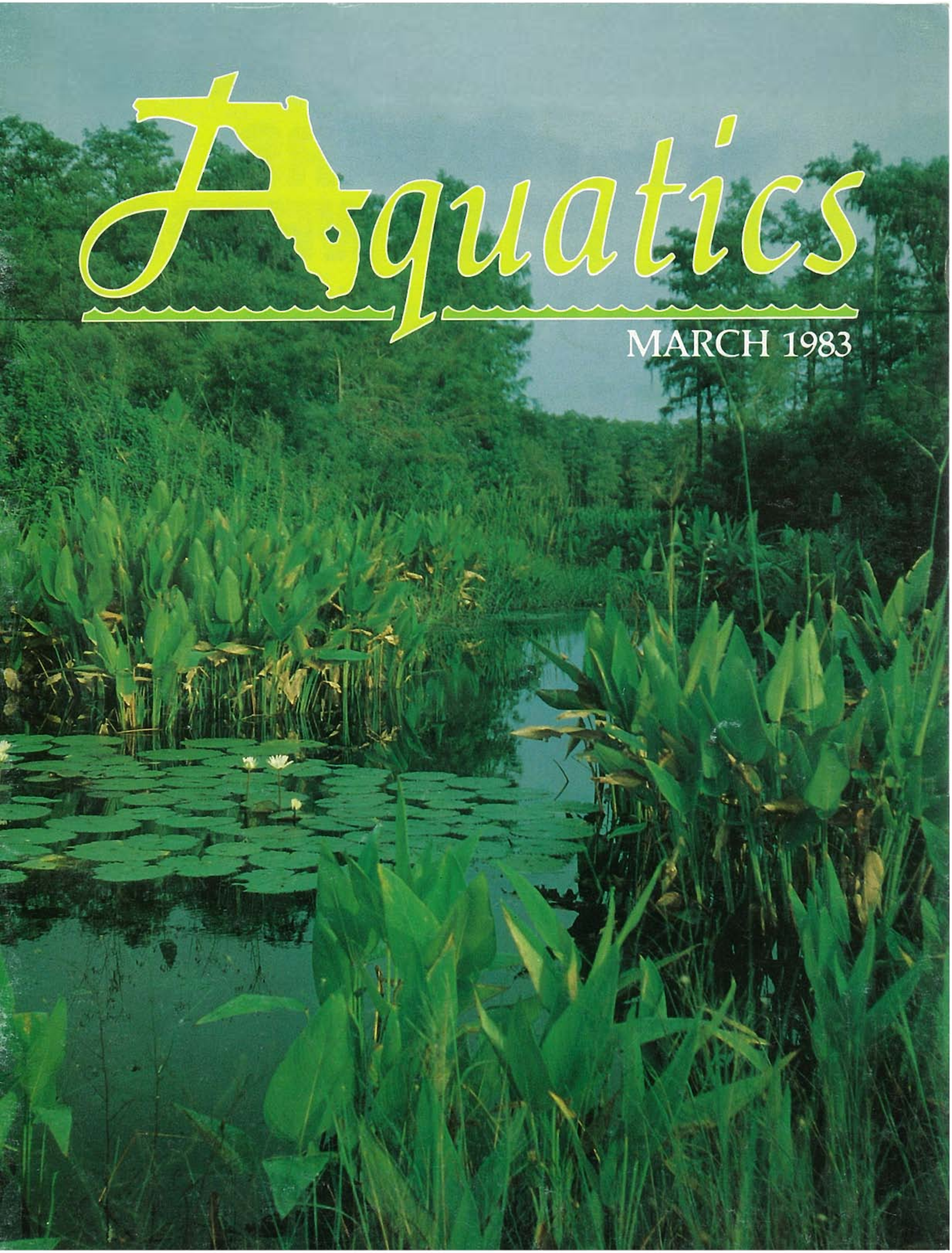
Aquatics

MARCH 1983



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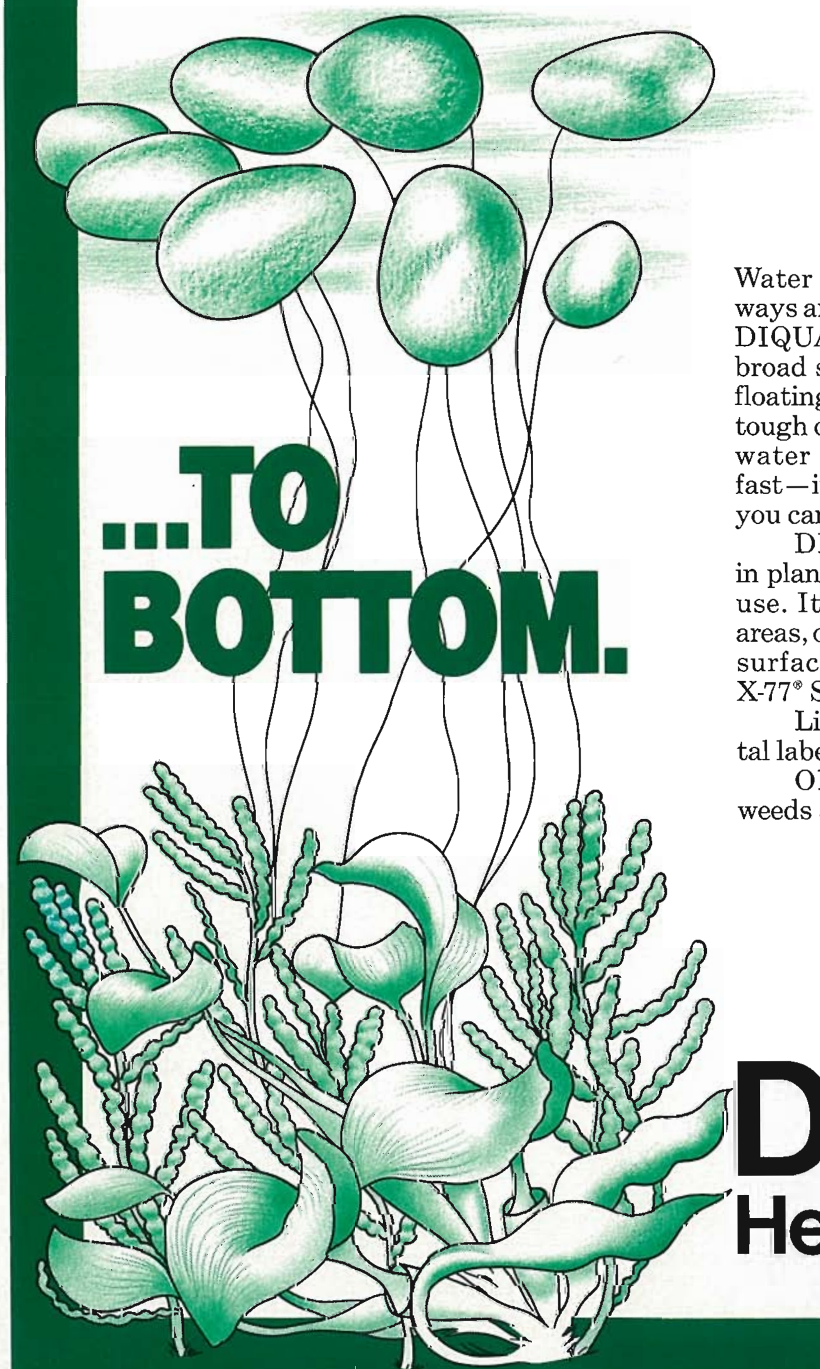

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EDITORIAL

Recently, DNR has informed the Aquatic Plant Advisory Council of some major statutory changes they are considering to propose to the legislature on the Aquatic Plant Control Acts.

Consideration is being made to increase penalties for permit violations up to $10,000 per day per offense. Justification on this change appears very weak since only a few blatant violations have occurred over the past decade. Existing laws, if enforced, are more than a sufficient deterent. Fees to support the state's cost of the permit programs are also being investigated.

The major change being considered would do away with the inter-county, intra-county definition of waters and the state would be responsible for the control of aquatic plants in all waters of the state.

While conceptually this would reduce confusion on agency responsibility for aquatic plant control, it would also require a tremendous increase in funding levels to provide proper maintenance control throughout the state. The funds appropriated for the state funding program would be used by the state to support this change. Local governments would potentially be relieved of their financial responsibilities and would more than likely become "real poor" if asked to contribute funds for control activities should state funds run short. Currently local governments are spending approximately 7 million dollars along with the 2.2 million provided by the state for intra-county aquatic plant control. If the level of maintenance control is to continue, the legislature would have to increase the aquatic plant control trust fund budget considerably.

This proposed legislation is not contingent on an increase in the trust fund. If adopted in this form it could result in a prioritized system for aquatic plant control in areas of local interest by state government. *The reasoning and motives for these changes should be clearly understood and justified over the existing legislation. Local governments may find themselves tangled up with state government on the decision of whether or not weeds need to be controlled and to what degree, as well as competing with their neighbors for a very limited amount of funds to cover the state. Ultimately local entities may have to provide more funds to manage aquatic plants at a desirable level for their constituents. If the existing system is not working it should be changed; however, if there is only a squeak in the wheels of bureaucracy then all that's needed is some grease to remove the squeaks.*

THE COVER

Six mile Cypress Swamp, Lee County

Photo Don Doggett

Aquatics

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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.

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WATER HEMLOCK

Cicuta mexicana (Coult.) and Rose.

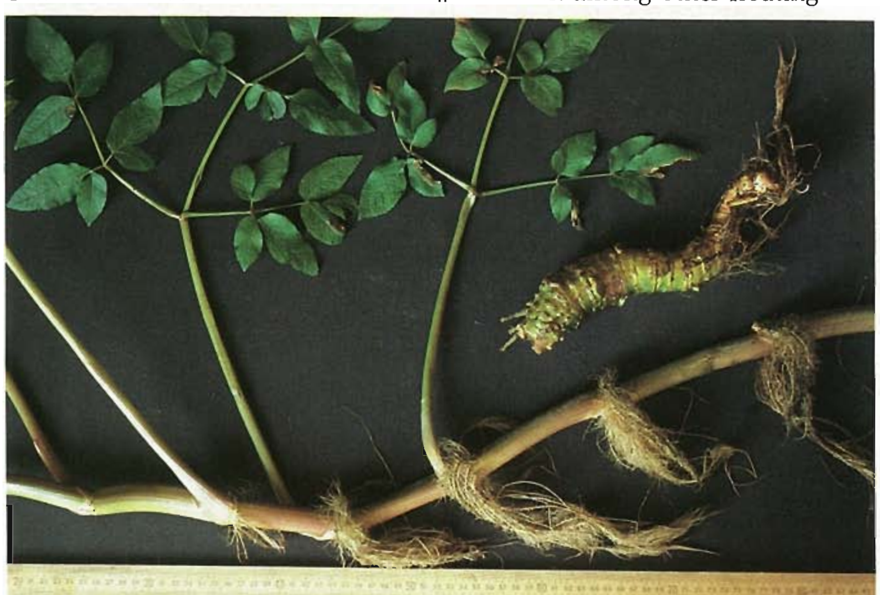
by Brian Nelson, Biologist — Dept. of Natural Resources

Most books and identification classes on local flora draw attention to poisonous plants and for good reason. Anyone whose work or recreational pursuits are out of doors should be able to identify poisonous plant species and avoid them. Water hemlocks, belonging to the genus *Cicuta*, are poisonous aquatic plants which may be frequently encountered by those who collect or control aquatic vegetation. The water hemlocks belong to the Umbellifereae or carrot family. This large family of mostly herbaceous plants contains over 200 genera and roughly 3000 species. About 15 of these genera contain aquatic species. The most common and easily recognized non-poisonous representative of this family is water-pennywort *(Hydrocoytle spp.)*.

Eight to ten species of *Cicuta* thrive throughout the United States. All are considered poisonous to humans and livestock. Two species are common to the Southeastern United States, *C. maculata* L. and *C. mexicana* Coult. and Rose. *C. mexicana* is the species usually found in Florida. This native emergent species is found growing in marshy areas or floating in tangled mats along many of the large, slow flowing rivers in North and West Central Florida. Rivers where *C. mexicana* is found include the Wacissa, Sopchoppy, St. Marks, Wakulla, Escambia, Ichetucknee, Withlacoochee and others.

Tangled, floating mat of water hemlock growing in association with water-hyacinth, frogs-bit and other floating species.

Water hemlock has alternate, pinnately compound leaves which clasp the stem at their base. The leaves are termed compound because each mature leaf is divided into 40 or more distinct leaflets. These individual leaflets are lanceolate shaped with sharply serrated edges. Leaflets occur in clusters of two or three except toward the terminal end of the leaf where they occur singularly. The stems are smooth, hollow and striped with green and purple, which gives them a purplish tint. In water, these decumbent stems float upon the surface rooting at the nodes and form an intertwined network among other floating species such as water-hyacinth *(Eichhornia crassipes* [Mart.] Solms.) and frog's-bit *(Limnobium spongia* [Bosc.] Steud.).



Hollow, floating stem of water hemlock showing alternate, compound leaves. An enlarged and detached tuber-like section of a stem is also shown.

Small white flowers occur axillary or terminally in compound umbels or disc shaped clusters upon a large erect flowering stem. Each flower produces a round, deeply ribbed and viable seed. In addition, *C. mexicana* produces tuber-like reproductive structures which aid its dispersal in aquatic habitats. These structures are formed in the fall when sections of its horizontal stems become swollen and enlarged with storage products. The enlarged portions of the stem which contain one or more lateral shoots, separate and drift away to establish in another area. *C. mexicana* is the only water hemlock species which produces these tuber-like structures.

Water hemlocks are often confused with related species of the carrot family including cowbane *(Oxypolis rigidior)* [L.] Raf.) and water parsnip *(Sium Suave* Walt.). Misidentifying these and other species as water hemlock has resulted in numerous and misleading common names. Such names include snakeroot, cowbane, spotted hemlock, wild parsnip, poison parsnip and others. Distinguishing water hemlock from these species is easily accomplished by vegetative

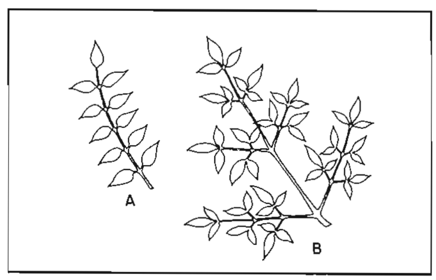


Figure 1. Compound leaves: (A) Simple pinnately compound leaf; (B) decompound leaf. Drawing by Don Schmitz, DNR.

characteristics and habitat distribution. Water hemlock is distinguished from cowbane and water parsnip by the number of times its leaves are divided. The leaves of water hemlock are several times pinnately compound or decompound (divisions that are themself divided), while the leaves of cowbane and water parsnip are only once pinnately compound (Figure 1). Very few aquatic species in this family have decompound leaves. The leaflets of those species that are decompound are

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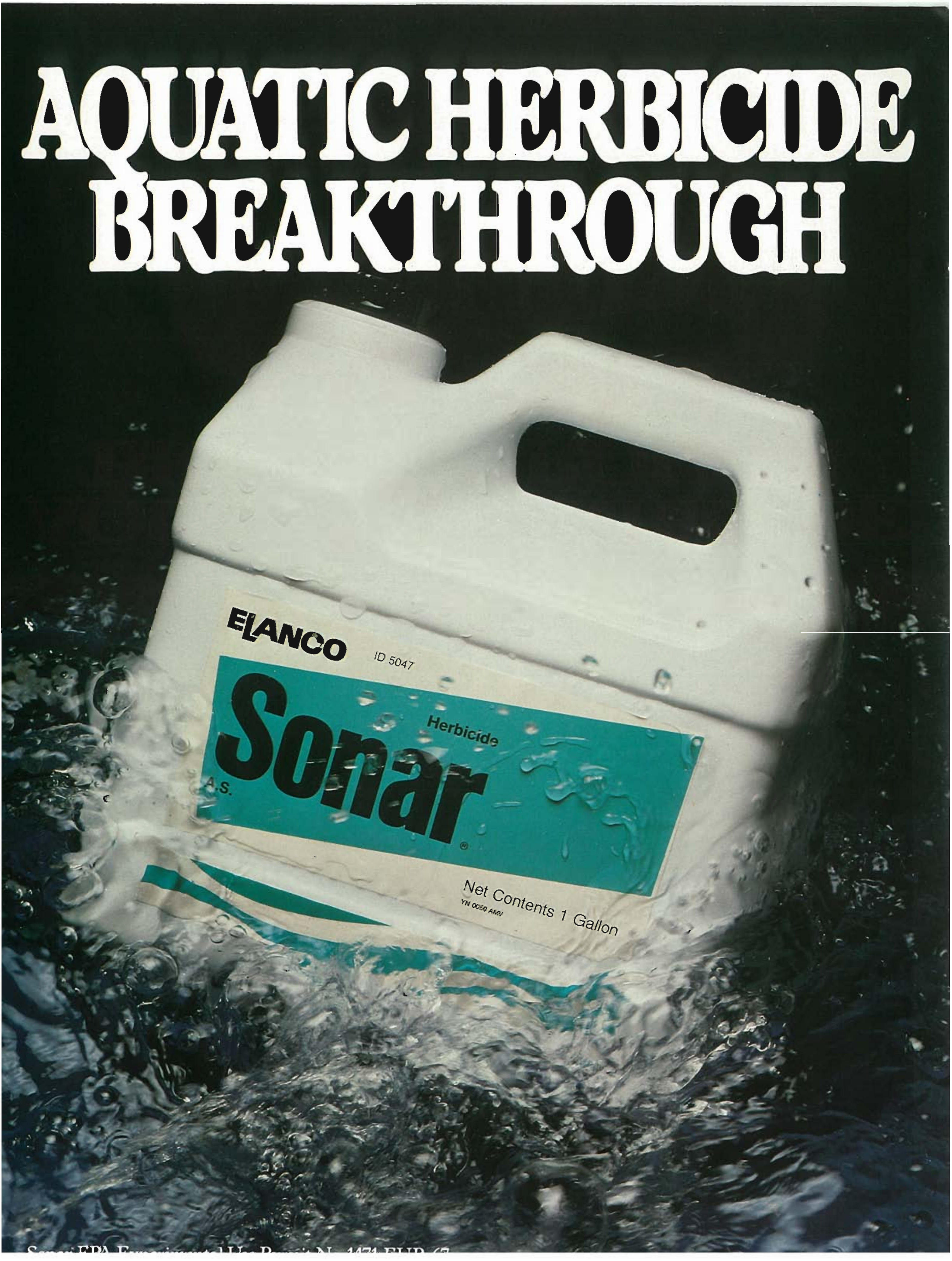
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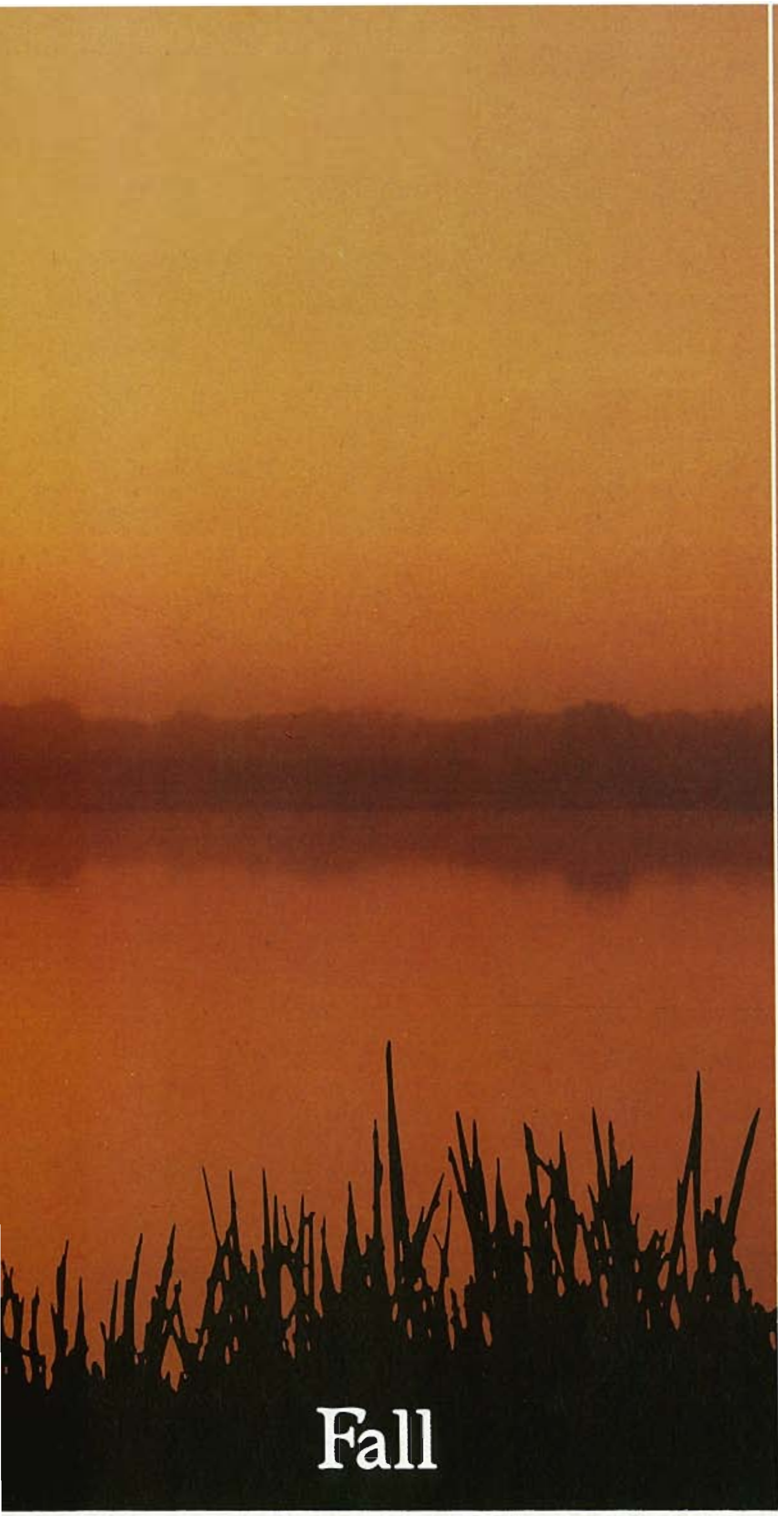

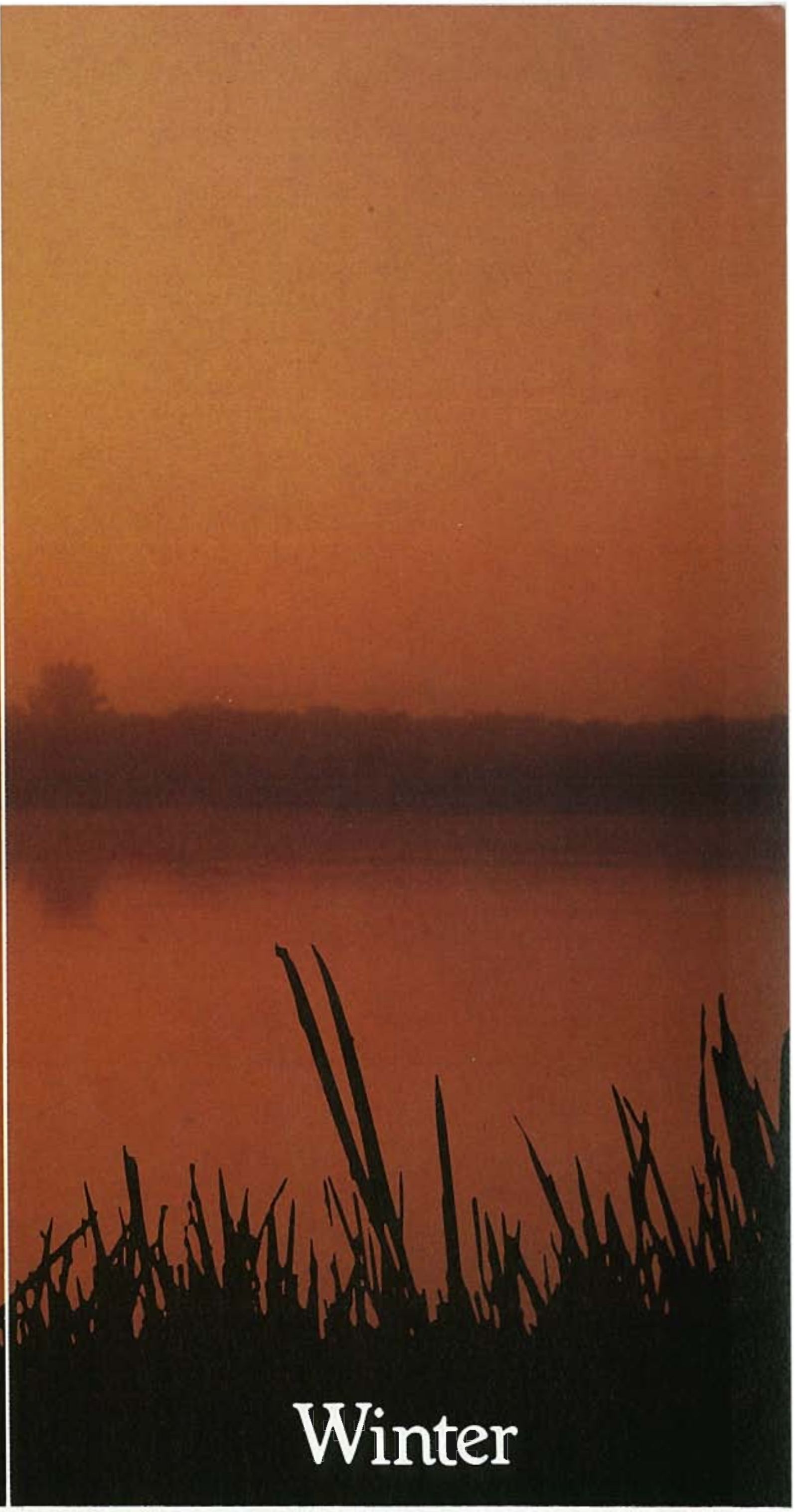

wildlife, or nearby trees and shrubs.

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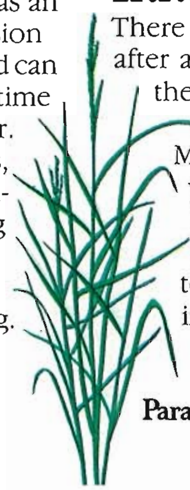
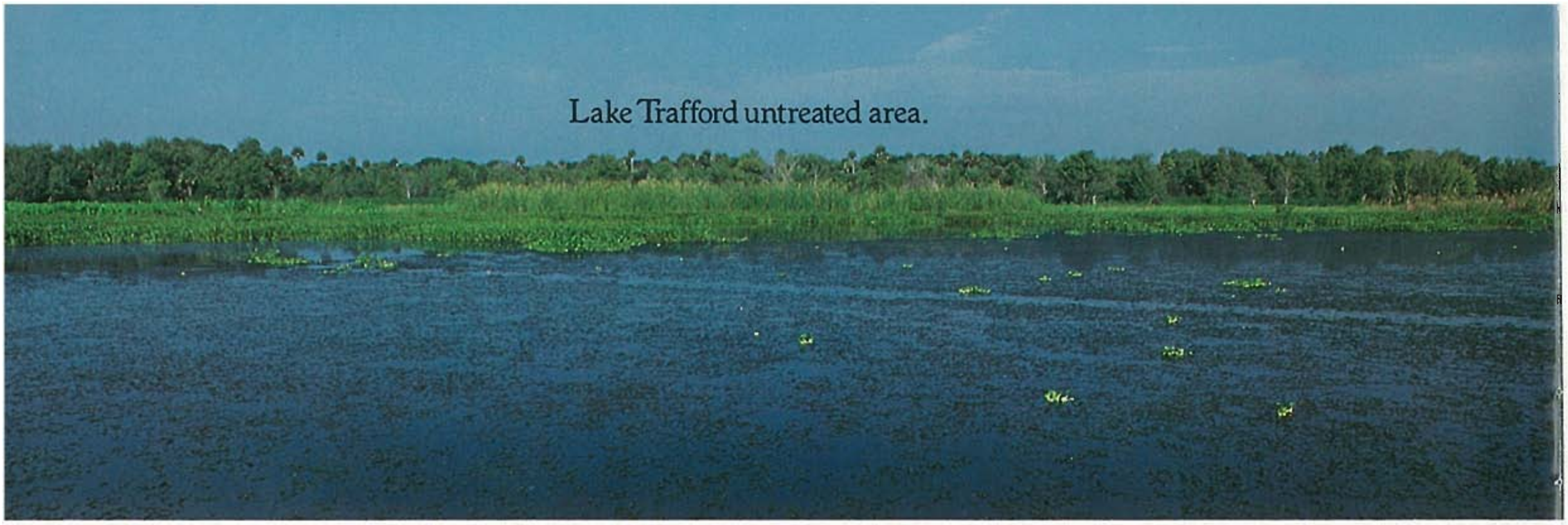
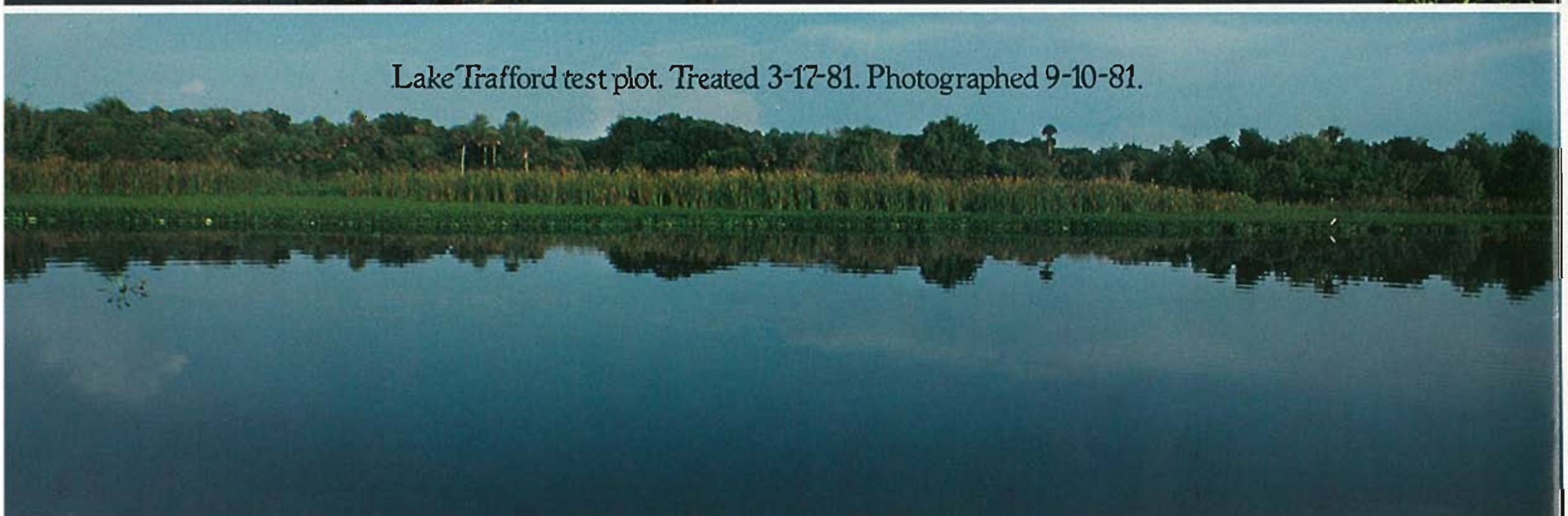


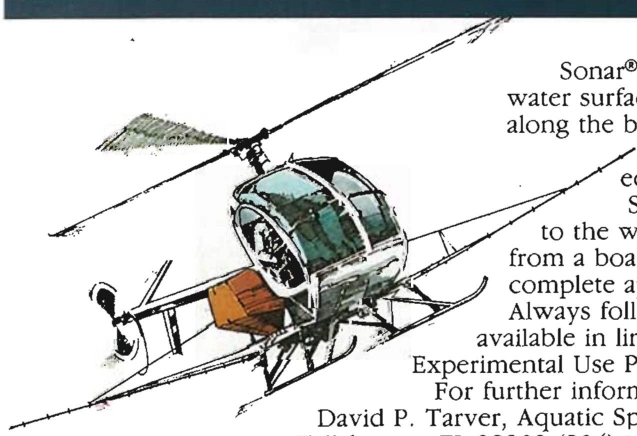
Paragrass



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.

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linear or filiform and thus not easily mistaken for water hemlock with its lanceolate shaped leaflets.

Another distinguishing characteristic of water hemlock is the veination of its leaves. The majority of the principle leaf veins in *Cicuta* spp. appear to terminate in the notches of the serrated leaf edges and not the tips of the serrations.

The genus *Cicuta* is considered by several authors to contain the most virulently poisonous plants of the northern temperate zone. Human poisonings and deaths are contributed to the collection and ingestion of the roots of water hemlock which are mistaken for roots of edible species. Livestock have been poisoned by ingesting water hemlock after normal browse has been severely depleted. The entire plant is toxic, although the roots and lower stems are considered to be more toxic than the foliage.

The yellowish oily liquid found in the roots and lower stems, contains an alcohol compound which is the toxic component of *Cicuta.* Cicutoxin, as it is called, rapidly affects the central nervous system. Symptoms of Cicutoxin poisoning occur in stages and include excessive salivation and tremors which progress to violent convulsions. Other symptoms include abdominal pain, dialated pupils, elevated temperature and delirium. Death may result from respiratory failure due to paralysis. Inducing vomiting when the symptoms first occur increases the chances of recovery. Refer to *Poisonous Plants of the U.S. and Canada* (Kingsbury, J.M. 1964) for additional information concerning the toxic properties and reported poisonings attributed to the hemlocks.

Twenty-five acres of water hemlock were found statewide in rivers during the 1982 aquatic plant survey conducted by the Department of Natural Resources. The largest amount, 14 acres, was found in the Withlacoochee River. This species was not found in any of the 299 lakes surveyed. Water hemlock occasionally blocks small tributaries of rivers or forms stable floating mats in association with water hyacinths. It is often controlled along with water-hyacinths in these situations with 2,4-D or Diquat. □

From Citrus County Aquatic Plant Control — "You know it's really gonna be a bad day when. . . .

1) *You pull a log out of the water and realize it has teeth.*
2) *You, for the first time, arrive at work early and find out it's Saturday.*
3) *You drop your D. O. Kit overboard.*
4) *You pick up the newspaper and your department makes the headlines.*
5) *You post a warning sign and the "Bad Dog" sign means just that.*
6) *You turn the curve on a full plane and realize the canal is a dead end.*
7) *You arrive at the boat ramp and realize you forgot the boat.*

COMPARISON OF THE GRASS CARP AND HYBRID GRASS CARP

by Ms. Janine L. Callahan and Dr. John A. Osborne
Biology Dept. University of Central Fla., Orlando, Fla.

INTRODUCTION

Since its introduction into the United States, the grass carp *(Ctenopharyngodon idella* Val.) has been widely used in research and operational schemes for weed control (Guillory and Gasaway, 1978; Sutton, 1977). Its ability to control noxious submersed aquatic plants is unquestioned. Grass carp are known to prefer succulent, submersed plant species which include many plants which reach noxious levels in Florida lakes (Prowse, 1971). It stands to reason that the use of this herbivorous fish in weed control operations would provide a low cost, effective control method. It is now possible to predict the success of hydrilla control with grass carp in Florida using a stocking density based upon three factors: 1) the size of the grass carp at the time of stocking, 2) the season (month) in which the fish were stocked, and 3) the biomass of hydrilla in the lake when the fish are stocked (Osborne, et al., 1982). Hydrilla is eliminated from Florida freshwater lakes when 20 fish (0.5 -0.9 kg mean wt) metric ton^{-1} - fresh weight hydrilla are stocked in March at the beginning of the growing season.

Because of various state laws regulating its use, the grass carp is allowed in only Arkansas, Mississippi, Alabama and Kansas (Lynch, 1979); in some other states, the fish can be sold when a permit is obtained. In Florida, the grass carp were stocked in freshwater impoundments of equal to or less than 10 ha under Florida Rule 16C-21; this rule was abolished in 1980. Presently in Florida the grass carp is restricted to research use in waters that contain grass carp stocked prior to 1980; such waters are permitted under Florida Rule 39-8. The basic argument against the use of the grass carp is that the fish may escape into flowing waters where this river species may reproduce and eventually become overpopulated, and finally eliminate native aquatic vegetation to the extent of causing harm to other fishes and wildlife. While little positive data exists to support this claim, the controversy over the use of the grass carp in Florida and elsewhere endures. It was this controversy over the use of the grass carp for weed control that kindled the development of the hybrid grass carp from the cross between the male bighead carp *(Hypophthalmichthys nobilis* Rich. formerly *Aristichthys nobilis* Rich.) and the female grass carp.

Hybridization between herbivorous fish and other cyprinids have been attempted since 1964 (Sutton, et al., 1981). The hybridization of the bighead carp and the grass carp was first performed in 1968 in Szarvas, Hungary with triploid (2N = 72 chromosomes) hybrid grass carp reported by Marian and Krasznai (1978). Utilizing to some extent the spawning techniques of Z. Krasznai, J. Bakos and T. Marian (1978), hybrid grass carp were first spawned in the United States at the Malone and Sons fish hatchery, Lonoke, Arkansas (Lynch, 1979; Sutton, et al., 1981). Malone is reported to have successfully spawned three trials in June, 1979. Even though survival of the young was a major problem, several thousand fingerlings were produced and dispersed for research during 1979. The hybrid grass carp received in Florida were used in early research trials by the University of Florida (D. Sutton), the Florida Game and Fresh Water Fish Commission, Lee County Hyacinth Control District (J. Cassani) and the University of Central Florida.

Sutton, et al. (1981) compared ten specimens of similar sized grass carp, bighead and 1979 hybrid grass carp to examine morphometric characteristics. In this early report (no account was made for chromosome number in the hybrid) it was found that the hybrid grass carp had features similar to the grass carp which included the structure of the pharyngeal teeth, the size of the

Continued on page 12

head, the position of the eyes, and terminal mouth. Intermediate features listed included the number and size of the scales, the size of the caudal fin, the size of the mouth, the length of the gill rakers, and the insertion of the dorsal fin relative to the ventral fin.

Early feeding trials with fingerling 1979 hybrid grass carp were conducted by Cassini (1981). The fingerling hybrid grass carp was observed to feed upon succulent vegetation, but in some instances were observed to feed upon mosquito larvae and small leeches. The parent bighead carp is planktivorus. He listed the order of plant preference for the hybrid grass carp fingerlings as *Ceratophyllum demersum, Najas quadalupensis, Hydrilla verticillata, Hygrophila polysperma* and *Myriophyllum pinnatum.* Sutton (1980) found that fingerling hybrid grass carp reduced the height of eelgrass and reduced the growth of southern naiad and Illinois pondweed, but apparently did not feed upon hydrilla or Eurasian watermilfoil in tank studies. He found a variable growth rate for the hybrid grass carp when fed hydrilla with the average daily weight gain varying from a high of 5.26 g $fish^{-1}$ day^{-1} to a loss of 1.8 g $fish^{-1}$ day^{-1}; the average growth rate of all his trials using the 1979 hybrid grass carp was 1.1 g $fish^{-1}$ day^{-1}.

Early karyotyping of the 1979 hybrid grass carp revealed that all of the fish spawned at the Malone and Sons Fish Hatchery were triploid (2N = 72 chromosomes; each parent, 2N = 48 chromosomes) (Beck, et al., 1980). This lead to the belief that the hybrid grass carp was sterile, which probably resulted in the overwhelming early acceptance and widespread stocking of the fish in Florida. It was soon learned that the 1979 spawn of hybrid grass carp from the Malone and Sons Fish Hatchery did not contain 100% triploid individuals, but something less (the exact number is unknown). During the spawning of the 1980 hybrid grass carp, the technique (Lynch, 1979) used in the spawning at the Malone and Sons Fish Hatchery was modified (heat shock of the egg to insure that the polar body was maintained during fertilization) and greater survival of the larvae was accomplished. The procedural change resulted in a majority of diploid rather than triploid offspring with these fish receiving 24 chromosomes from each of the parents instead of 48 chromosomes from the grass carp egg and 24 chromosomes from the bighead sperm. The failure of the 1980 hybrid grass carp as a weed forage fish and its high mortality is accredited to the high percentage of diploid fish produced. Magee and Philipp (1982) found that from 40% to 68% (average of 44%) of the 1980 hybrid grass carp from the Malone and Sons Fish Hatchery were diploid, but that nearly all of the 1979 and 1981 spawn was uniformly triploid. Based on electrophoresis and histochemical procedures, they concluded that there may be some question as to the sterility of the 1980 hybrid diploids and furthermore, data for the bighead carp and grass carp more closely resemble data for subspecies or sibling species rather than distinct genera. They state, "This puts the generic status of these two species somewhat in question and this may affect predictions of the sterility of the F_1 hybrid.". Several thousand 1980 diploid hybrid grass carp were stocked into Florida freshwater lakes.

Although a large number of lake trials were undertaken in Florida to determine the efficacy of the hybrid grass carp at weed control, early on it was recognized that feeding trials using grass carp and hybrid grass carp to compare growth rate, feeding rate, and efficiency of food conversion was essential to the evaluation of the hybrid grass carp. These data provided a comparison of the 1979, 1980 and 1981 spawns of hybrid grass carp and have been of utmost importance from the standpoint of explaining the lack of success of the hybrid grass carp as a weed control agent. Early feeding trials of the 1979 and 1980 hybrid grass carp and similar sized grass carp have been reported (Osborne, 1982); these trials shall be reviewed from the standpoint of comparison with the 1981 hybrid grass carp.

METHODS AND MATERIALS

The hybrid grass carp (1979, 1980 and 1981 spawns) and grass carp spawned in 1980 and 1981

Table 1. Mean ratios of external features, pharyngeal teeth, branchial arch filaments and gill rakers for the grass carp and 1979, 1980, 1981 hybrid grass carp.

Mean Ratios	1980-81 Grass Carp	1979 Hybrid Grass Carp	1980 Hybrid Grass Carp	1981 Hybrid Grass Carp
Head length/SL	0.23	0.27	0.26	0.27
Trunk length/SL	0.52	0.45	0.47	0.45
Caudal length/SL	0.29	0.33	0.32	0.33
Dorsal fin length/SL	0.18	0.22	0.21	0.23
Pectoral fin length/SL	0.19	0.27	0.25	0.24
Pelvic fin length/SL	0.15	0.19	0.18	0.19
Anal fin length/SL	0.13	0.16	0.16	0.17
Caudal fin length/SL	0.23	0.27	0.26	0.28
Number scales above lateral line	6.2	10.0	9.7	9.7
Number scales below lateral line	5.0	6.3	6.0	5.9
Number scales in lateral line	40.7	51.3	50.8	48.3
Gut length/SL	3.01	2.29	2.46	2.95
Raker length/SL	0.04	0.05	0.05	0.05
Number rakers on branchial arch	19.6	37.9	39.2	38.8
Number rakers on pharyngeal arch	12.5	28.3	28.5	29.6
Filament length/PAL	0.34	0.30	0.28	0.31
Branchial arch length/PAL	1.05	1.37	1.30	1.24
Branchial arch breadth/PAL	0.06	0.04	0.04	0.04
Height large teeth/PAL	0.26	0.18	0.19	0.19
Height small teeth/PAL	0.12	0.07	0.08	0.08
Width large teeth/PAL	0.09	0.06	0.06	0.07
Width small teeth/PAL	0.04	0.02	0.03	0.04
Relative mean erythrocyte volume[a]	4.4	8.0	7.6	10.1
Relative mean erythrocyte nucleus volume[a]	0.67	0.92	0.75	1.02
% hybrid grass carp with a larger ENV than grass carp	—	100.0	46.2	93.3
N=	19	14	25	15

SL = Standard Length
ENV = Erythrocyte Nucleus Volume
PAL = Pharyngeal Arch Length
[a]In units of ocular micrometer observed at 1000 X.

that were used for comparison were produced at the J.M. Malone and Sons Fish Hatchery in Lonoke, Arkansas.*

RESULTS AND DISCUSSION

A comparison of the morphology of the hybrid grass carp and grass carp was undertaken to determine whether the morphology of the hybrid grass carp produced in 1981 was significantly different from the hybrid grass carp spawned in 1979 and 1980, as well as to compare the feeding rate, growth rate and feeding efficiency of the 1981 hybrid with results obtained from studies with earlier spawns. As shown in Table 1, several of the external morphological characters of the three groups of hybrid grass carp were quite similar, in particular the ratios of head length, trunk length and caudal length to standard length. These variables were found to be significantly different from those of the grass carp. Only slightly different values for the head length/standard length ratio were reported by Sutton et al. (1981), Berry and Low (1970), and Kilambi and Zdinak (1981), but in each case the relative values were found to be greater for the hybrid grass carp than the grass carp. Overall, the grass carp had smaller head and caudal length/standard length ratios, while hybrid grass carp tended to have a smaller trunk length/standard length ratio. While the fin length/standard length ratios were similar between the year classes of hybrid grass carp, the ratios of the dorsal, pectoral, pelvic, anal and caudal fin length to standard length were larger than that for the grass carp, Table 1. The larger size of the fins of the hybrid grass carp were quite obvious when compared to the grass carp, undoubtably a feature obtained from the male parent. Differences in the number and size of the scales were readily apparent. In all year classes of hybrid grass carp, there was a significantly greater number of scales above, below and in the lateral line (due to the smaller size of the scales) than for the grass carp. The number of scales in lateral line of the hybrid grass carp ranged from 45 - 53, with 9 - 11 scales above and 5 - 7 scales below the lateral line. For the grass carp, the number of scales in the lateral line ranged from 37 - 44, with 6 - 7

**For specifics on the standard tests used for morphometric, feeding, growth and efficiency comparisons contact the authors.*

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scales above the lateral line and 5 scales below the lateral line. We agree with Berry and Low (1970) that the number of scales for the hybrid grass carp is intermediate between the parents and tend to be more variable than either parent.

The relative gut length of the 1981 hybrid grass carp more closely resembled that of the grass carp than either the 1979 and 1980 hybrid grass carp (Table 1); it also was one of the few important morphological differences that was found between the year classes of hybrid grass carp. The 1979 and 1980 hybrid grass carp tended to have smaller gut length/standard length ratios than that of the 1981 hybrid grass carp.

One other important feature that was found to be different between the spawns of hybrid grass carp, was the reduction in the number of deformities in the gill rakers of the 1981 hybrid grass carp. The gill rakers of the 1980 hybrid grass carp were frequently deformed (perhaps from the high incidence of diploidy in that spawn), while the gill rakers of the 1979 and 1981 hybrid grass carp were usually well formed. Berry and Low (1970) noted that gill rakers in the bighead are long and closely arranged, but that grass carp have very small and sparsely arranged gill rakers; the hybrid grass carp appear to be intermediate, differing from both parental stocks in the length and number of gill rakers present. In general, the rakers of the five branchial arches were found to be longer and more numerous in all age groups of hybrid grass carp than those of the grass carp, Table 1. The gill filament/pharyngeal arch length ratios for the hybrid grass carp were smaller than those of the grass carp, concurring with the results obtained by Berry and Low (1970). Relative branchial arch lengths of the 1981 hybrid grass carp were slightly less than that of the other year class of hybrids, but was still significantly greater than those of the grass carp. In general, branchial arches in the grass carp tended to be short and broad, while those of the hybrid grass carp were thinner and more elongated. The teeth on the pharyngeal arches of the grass carp were generally larger than those of the hybrid grass carp; however, no significant difference was found between the four groups of fish for the width at the base of the smaller teeth, Table 1. The teeth of the grass carp were always in two rows, with teeth formulae of either 2,4-5,2 or 2,5-4,2, while the teeth of the hybrid grass carp were in one or two rows on each arch (more often only one row) with a variety of teeth formulae.

The relative mean erythrocyte volume and relative mean erythrocyte nucleus volume were significantly larger in all year classes of hybrid grass carp as compared to those of the grass carp, Table 1. A triploid cell was assumed if it had a mean nucleus volume of 50% greater than those of the grass carp (diploid); such was the case for the 1981 hybrid grass carp which had a relative mean erythrocyte nucleus volume of 1.02 compared to 0.67 for the grass carp. The group of hybrid grass carp having the highest number of diploid fish was the 1980 year class; only 46.2% of the fish sampled had relative mean erythrocyte nucleus volumes larger than that of the grass carp. All of the 1979 hybrid spawn had relative mean erythrocyte nucleus volumes greater than that of the grass carp, Table 1.

While the 1981 hybrid grass carp had a longer relative gut length, an improved structure of the gill rakers, and less morphological deformities as compared to the other spawns, these fish were not found to have growth rates that were significantly higher than for hybrids from previous spawns. As shown in Table 2, the mean weight gain fish^{-1} day^{-1} of 1981 hybrid grass carp was almost identical to

Table 2. Weight gain, consumption rate and feeding efficiency of grass carp and the 1979, 1980, and 1981 hybrid grass carp in the UCF experimental ponds.

	1981 G. Carp	1981 G. Carp	1979 Hybrid	1980 Hybrid	1981 Hybrid
Initial Mean Wt. (gm)	858.0	1,270.0	754.0	178.0	201.9
Final Mean Wt. (gm)	1,270.0	1,600.0	812.0	316.0	253.7
Mean Wt. Gain Fish^{-1} Day^{-1} (gm)	20.7	29.7	2.8	3.9	3.7
Egeria consumed Fish^{-1} Day^{-1} (gm)	983.3	1,117.9	278.0	76.1	30.0
Efficiency (%)	2.1	2.4	1.0	5.2	14.8
Duration of Trial (days)	14	14	20	35	14

that of the 1980 hybrids (which were primarily diploid). The growth rate for the 1981 hybrids was found to be eight times less than that of similar sized grass carp. The amount of vegetation *(Egeria densa)* consumed by the 1981 hybrid grass carp (approximately 200 g fish) was only 30.0 g $fish^{-1}$ day^{-1}; or approximately 15% of its body weight per day. This rate was less than one-half the rate obtained for the 1980 hybrid grass carp and about one-tenth the rate for the 1979 hybrids. Small grass carp, on the other hand, tend to consume their body weight per day of vegetation, Table 2. The slow growth and low feeding rate of the 1981 hybrid grass carp are accompanied by a higher efficiency for food conversion (plant material into fish flesh). The food conversion efficiency of the 1981 hybrid grass carp was nearly seven times higher than that of the grass carp and three and fifteen times higher than the 1979 and 1980 hybrids, respectively. The 1981 hybrid is more efficient at converting food and consequently requires less food for growth and maintenance. From this aspect, one must conclude that the 1981 hybrid grass carp would be less effective as a weed control agent when compared to the other hybrid grass carp year classes, and indeed, is the apparent reason for the lack of success of this year class of hybrid grass carp as a weed control agent.

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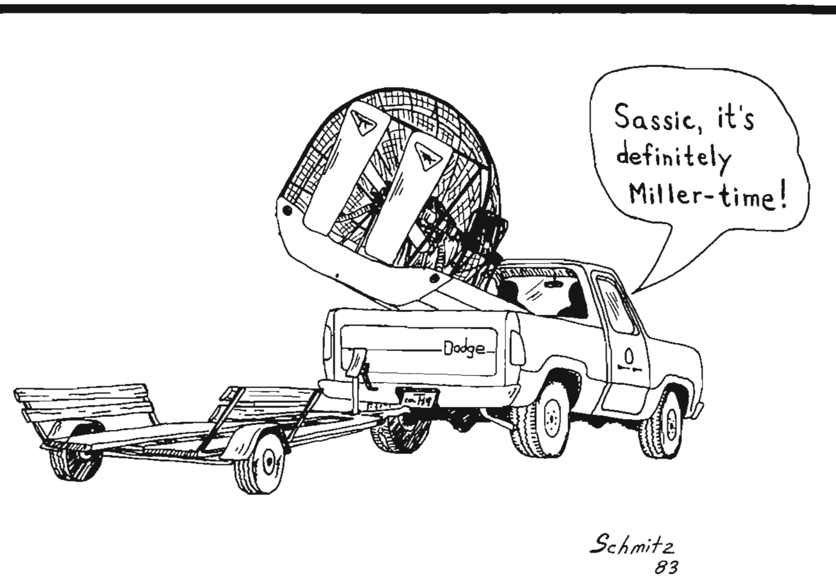

From the Editor:
A cartoon strip has been added to "Aquatics" to portray some of the many humorous events of the everyday work in the field. Don Schmitz, DNR, agreed to draw for us, so submit your ideas to me. Any suggestions for a name of this series will be welcomed.

AN INTRODUCTION TO LIMNOLOGY

by Ted R. Batterson[1]

Limnology is the study of freshwater, with emphasis on the inter-relationships among the organisms that live there and how they are affected by changes in their physical, chemical, and biological surroundings. It includes the study of flowing waters (rivers, streams, and canals) but I will limit this discussion to lakes and their watersheds.

I wish to emphasize that lakes and their watersheds are complex ecosystems and even though each has its "own unique personality," there are general similarities between lake types. I would also like to stress the short-lived nature of a lake basin, geologically speaking. Most lakes within the United States were formed less than 15,000 years ago after the last retreat of the glaciers. A lake basin can be thought of as a trap or catchment area for materials that are carried in from the watershed, or produced within the lake itself. The lake will eventually fill in and become a portion of the terrestrial landscape.

There are many ways in which lake basins can be formed. In the northern states many lakes are of glacial origin. In Florida, the majority fall into three categories: tectonic lakes, solution lakes, and man-made lakes. A tectonic lake forms as a result of changes in the earth's crust. In Florida, changes in the earth's surface and sea level have produced many risings and fallings of the peninsula. There is evidence that Lake Okeechobee was a large depression in the sea floor some 10 million years ago. The lake retained its form when the region was last uplifted to become land approximately 10,000 years ago. It is a large, shallow lake with an average depth of 3 meters. In surface area it is the second largest water body within the United States' boundaries, the first being Lake Michigan. Other Florida lakes, including Apopka and Weir, may have formed by the same uplifting process. Biological evidence to support this theory is the presence in these lakes of killifish whose closest relative is found in the estuaries along the nearby coast.

Solution lakes are those that are dissolved out of bedrock and the most important group of this type in North America occur in Florida. The entire Floridian peninsula is covered with limestone and in some regions is exceedingly thick. Percolating surface water or flowing groundwater dissolves the limestone at points of fractures or other weaknesses creating depressions that can fill with water. The majority of lakes in central Florida are sinkhole lakes which are of this type.

The third type of lake found in Florida is man-made. There are numerous kinds of this origin. Reservoirs result from the damming of rivers. Quarry lakes are formed in pits left after the removal of bedrock, which here in Florida is mostly limestone. Around the Tampa Bay area there are many small water bodies that have been created as a result of phosphate mining. Along roadways or other major construction sites the removal of earth to use as fill can create depressions that fill with water and are referred to as borrow pits. Ornamental or recreational lakes would also be included in this category.

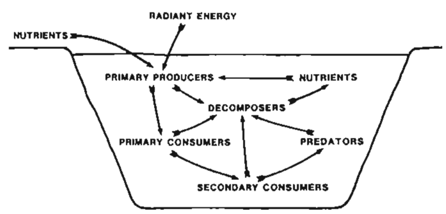

Figure 1. A generalized model of the various trophic levels found in a lake.

How is organic matter produced within the lake and what is its fate? To answer this question we must consider the process by which energy of the sun is captured and then is passed through successive food levels, or trophic levels (Figure 1).

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Primary producers (green plants) constitute the lowest trophic level. They capture the sun's energy to make organic compounds through the process of photosynthesis. The efficiency with which the energy of the sun (physical energy) is converted to chemical energy in the plant in most freshwater systems is in the range from 0.1 to 1%. These are low values but are close to those of many terrestrial plants.

The next trophic level consists of primary producers, or herbivores, animals that feed on green plants. Water fleas and mayfly nymphs would be examples of animals included in this category. The amount of energy that is converted from plant tissue to animal tissue varies but typically is 10% in many lakes. This is a much higher efficiency than the first since it is just a change from one chemical form to another.

Secondary consumers (e.g.-dragonfly nymphs, water beetles, and small fish) prey on herbivores which in turn serve as food for higher level consumers called predators (e.g.- fish, wading birds, frogs, turtles, and alligators). The conversion efficiency between each of these two levels is again around 10%.

As a result of these high energy losses (at least 90%) associated with the passage of energy from one level of the food chain to the next, the amount of plant material required to produce a given weight of some predator (a bass) can be immense. This shows the importance of the primary producers within a lake.

The last trophic level to be considered is occupied by the decomposers, those organisms such as bacteria, fungi, and protozoans, many of which use oxygen in breaking down the dead organic matter from all the other trophic levels, releasing nutrients and producing carbon dioxide. Decomposition can also take place under conditions of little or no dissolved oxygen, but this is a much slower process. If decomposition cannot keep pace with the production of dead material this leads to a buildup of organic sediments which can gradually fill in the lake basin.

How quickly this filling in process or aging occurs is dependent on a number of factors. One is the shape of the basin. Some lakes are large and deep with steeply sloping sides while others are small and shallow. Obviously the large, deep lake will take longer to fill. Another factor is the rate at which sediments and nutrients are carried in from the watershed. The rate of nutrient inputs is important since it is usually what limits the amount of organic production within the lake itself. Climatic conditions, especially light and temperature also play a major role in the aging process.

Based on their biological productivity, lakes are classified along a continuum. Lakes of low productivity are termed oligotrophic, while those that are highly productive are termed eutrophic (Figure 2). Intermediate between the two extremes are mesotrophic lakes.

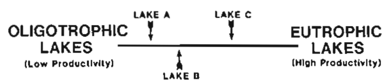

Figure 2. The continuum for lakes based on the productivity. Intermediate between the two extremes are mesotrophic lakes. The beginning status of Lakes A, B, and C are indicated by their position along the continuum.

Oligotrophic lakes are characterized by low concentrations of inorganic nutrients. There are few vascular plants or algae. Typically these lakes are relatively large and deep with clear water that allows light to penetrate to great depths. The lower layers of water have high concentrations of dissolved oxygen. Eutrophic lakes lie at the other end of the spectrum. They have high concentrations of nutrients which support a great amount of plant life, either algae or higher plants. In turn, all other trophic levels are increased. Unfortunately, the organisms that constitute these levels might not be desirable. Many highly eutrophic lakes support high levels of fish production but it might be a numerous, small, undesirable fish rather than large game fish. These lakes usually are shallow with thick layers of organic matter along the bottom and little or no dissolved oxygen in the lower waters.

Recently, Dr. Dan Canfield of the University of Florida, has completed a survey of 165 of the 7700 natural and artificial lakes in Florida. He found 42% to be mesotrophic and 35 % eutrophic. He relates the trophic state to the

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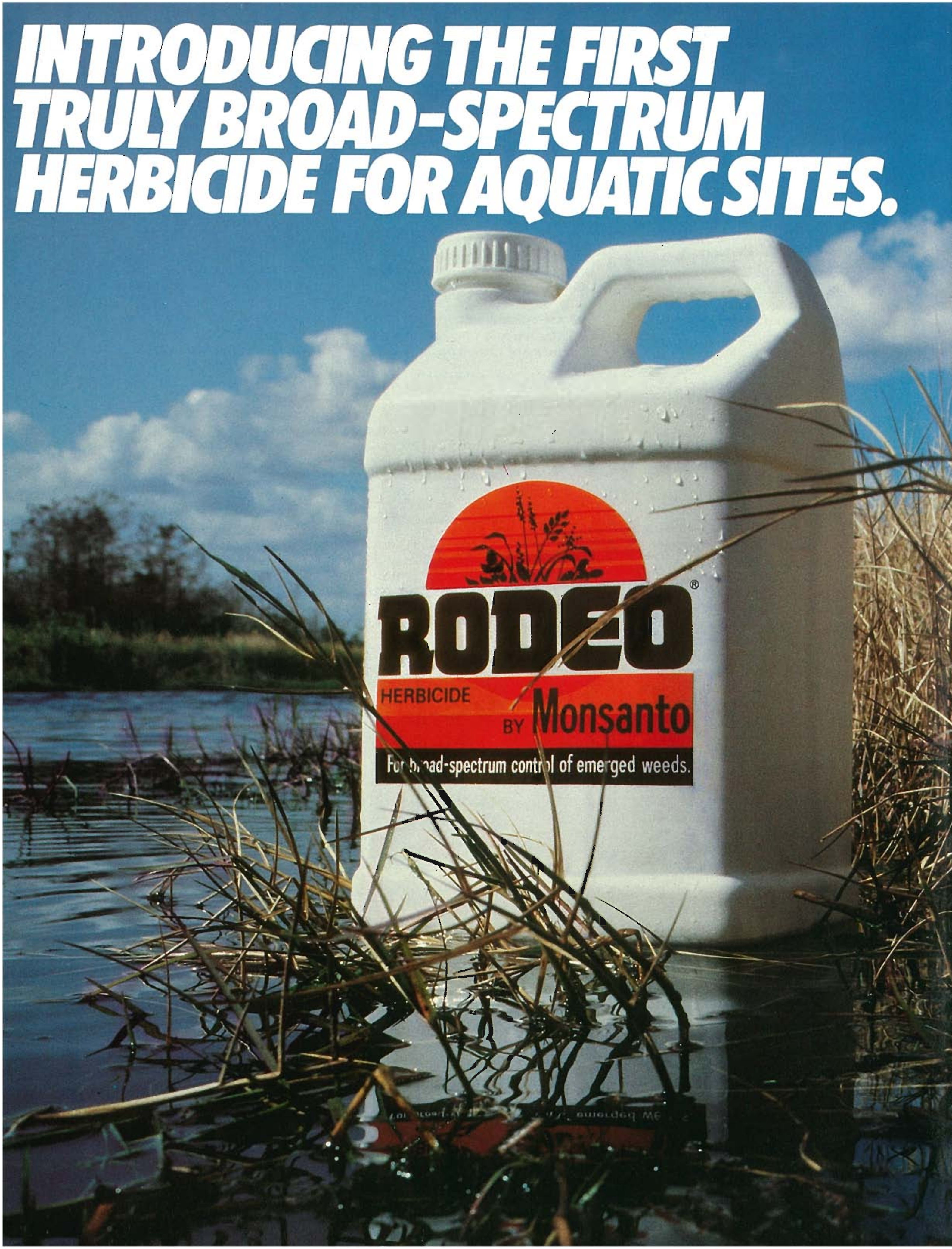
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Continued from page 17

mineral composition of the lake water and how that is related to the geology of the watershed.

The process in which the trophic status of a lake changes is called eutrophication. It is thought of as an aging process in which a young, relatively unproductive lake becomes older and more productive. It is important to know that not all lakes start at an oligotrophic status, but can begin at any point along the continuum (Figure 2).

There are two ways in which eutrophication can take place. One is a natural process which is slow, complex, and irreversible as the lake ages and fills in. The other is cultural, resulting from human activities. This is a more rapid process which results from the enrichment of the water body. The principal nutrients leading to this accelerated aging are nitrogen and phosphorus; the main sources of these being municipal sewage, industrial wastes, and agricultural run-off. Certain management techniques can reverse this type of eutrophication, but the lake can only be returned to the status it had before man-made disturbances occurred.

No matter how a lake becomes eutrophic, whether by natural processes or the result of human activities, it can lead to problems that pose a threat to its utilization. These lakes support prolific weed growth or nuisance algal blooms. This leads to deteriorating fisheries, impaired water quality, and lowered recreational use. The practice of managing the aquatic plants is a way of dealing with these problems. Unforturnately it is only a cosmetic act, temporarily alleviating the problem but not treating the underlying cause which is the increase in fertility. However, to limit plant growth by reducing the nutrients in a lake is not easily accomplished and sometimes is not technologically or economically possible. Therefore, we are left with managing the consequences of lake aging. □

AERIAL MONITORING OF AQUATIC PLANT MANAGEMENT PROGRAMS

by James T. McGehee — U.S. Army Corps of Engineers

The systematic approach to management of aquatic plants requires the timely gathering of information on the type of plants and extent of coverage within the managed water body before beginning operations. Likewise, monitoring of the operation is required to determine effectiveness and to allow changes in management strategy to take advantage of changing field conditions. Depending on the size of the water body involved this may be effectively accomplished by various means. Small ponds and lakes are easily reviewed from the shoreline or by boat. An increase in the size or number of the water bodies increases the time and resources required for adequate monitoring from the ground. At some point the manager's ability to review all of this area of responsibility from the ground will exceed his time or resource availability. At and beyond this point another means of monitoring must be used in order to maintain a true picture of the program status.

Aerial photography is the method that is usually considered first to fulfill this need. When accurate documentation is required and timing is not crucial aerial photography has been used quite effectively. However, the excessive expense involved in photographing a large area several times during the year and the turn around time between the flight and the availability of the acquired information to the manager, often make this method unacceptable. The plant infestation or location will likely change. An alternative is aerial visual monitoring. This procedure delivers information on a very large area in a very short time at a reasonable cost. The degree of accuracy is not high, but it is usually well within the range needed by the manager.

Aerial visual monitoring involves an observer being flown over the area of interest in a high wing, light aircraft or helicopter. Notes or voice tape recordings can be made of observed conditions or maps of the area marked to denote plant locations and approximate coverage while inflight. These recordings can then be used as a basis for determining progress and scheduling further operations. The information is immediately available in a usable form.

The key factor in aerial visual monitoring is the proficiency of the observer. There is no better way to develop this proficiency, than to actually spend time in the air trying to identify plants and visiting the areas afterwards on the ground to verify your identifications. Many of the finer points can be achieved more quickly by flying with someone proficient in aerial monitoring. The first flights should be of short duration at relatively low altitude (300 to 500 feet) and slow speed over areas familiar to the observer. Mapping of the vegetation should not be attempted at first other than notations of plant locations and tentative identification. The area covered, speed, and altitude can be increased as observer proficiency increases. Mapping of the vegetation can begin as soon as the observer is comfortable with his identification and can keep track of his location on the map. Aerial monitoring is very fatiguing. The constant drone of the aircraft engine and the concentration required in observing and identifying plants quickly tires the observer. The observer's desire and ability to adequately perform will decrease as fatigue sets in. Earplugs or earmuffs will help in reducing fatigue. However, large areas should be flown in a faster aircraft if possible to increase the attention span or be broken into several shorter flights. Beginning flights should not be over one hour in duration. Later, flights can be increased to 4 or 5 hours, if needed. A speed of 60 to 130 miles per hour and altitudes of 300 to 1200 feet are general ranges for monitoring. These must be selected by the observer based on his proficiency and the complexity of the area to be observed. Usually slow speeds are used at lower altitudes and faster speeds at higher altitudes.

Identification of plants from the air is considerably different from the ground identification. The observer is looking at the plants from a different perspective and at a greater distance. Plants must be distinguished by characteristics of a colony rather than individual plants. Some of the distinguishing characteristics of colonies are color and hue, texture, light reflectance, and location of the plant. Water hyacinths are dark green and water lettuce light green. However, water lettuce and duck weed (Lemna) may appear similar in color and hue. Closer observation will reveal a definite rougher texture to the water lettuce due to the patterns of light and dark caused by the larger leaves. The red phase of azolla is very characteristic and not easily confused with other plants. Nuphar presents a very rough texture due to the large leaves and shaded areas under the leaves. The leaf surfaces are also very shiny and light reflection from the shiny leaves can be seen from high altitudes. Floating plants collect in coves and against docks, bridges and other structures or may be seen moving across large expanses of deep water. Shoreline grasses and cattails are usually confined to shallow water areas. These differences together with color and texture can be combined to help in distinguishing between colonies.

Photo 1 - Aerial view of shoreline showing dense colonies of water hyacinth interspersed with lighter green water lettuce close to shore with beds of Vallisneria and bulrush further offshore.

Other factors can be used to tell the difference between colonies. The white flowers of fragrant waterlillies are very characteristic of the plant and can be seen from amazing altitudes. Familiarity with the water body over a period of time and the periodic occurrence of a species at certain times in certain areas is a great help in identification of plants. Even the most experienced observer will make mistakes because of similarities in different plants. Water pennywort has been misidentified as water hyacinths on numerous occasions by different observers. Mixed communities of plants confuse the color and texture pattern and may appear as the dominant species or mimic a colony of another species. For these reasons ground truthing of the aerial monitoring is needed. Ground truthing is a confirmation by inspection on the ground of the identifications made from the air. During the learning period ground truthing should be performed by the observer on all identifications. Later, truthing may be decreased based on the demonstrated accuracy of the observer. Where doubt exists, the area in question should be visited on the ground to verify the plant or plants present.

Selection of aircraft is made on several criteria. The most important criteria are availability, number of expected passengers, cruise speed, and cost. In all cases, the aircraft should physically provide an unobstructed view of the ground. All helicopters and high wind aircraft generally meet this requirement. Cessna models 172, 182, and 210 all have the wing mounted over the passenger area, but increase in seating capacity and/or cruise speed with the increasing model number. Current costs for charter of the fixed wing craft range from $70 for the 172 to $130 for the 210 for the Jacksonville area. At survey speeds this results in a cost of approximately one dollar per mile for aircraft cost. Full speed cruise for the 210 for general overviews of the work areas would cost approximately $0.70 per mile.

Photo 2 - Cessna 210 high-wing aircraft used for aerial monitoring.

Flight planning should be performed as far in advance as possible. The charter company or pilot should be notified of the general flight path at least one day before the flight so that the FAA required flight plan can be filed. If clearances through restricted flight areas will be needed, further advance notice to the pilot is required and the scheduling of the flight may be determined by when clearance is authorized through the restricted area. Before taking off sit with the pilot and make sure that he understands what you are doing, where you are going, and any special requirements you may have. Check to make sure that the windows are not dirty or fuel stained before taking off. Hours of trying to identify plant through dirty windows is miserable business. The rear passenger compartment is the best place to sit. The observers movements are not restricted by the plane's controls, the view is better, and the observer can look out of either side of the plane. Once under way do not be bashful about letting the pilot know how fast, slow, high, low or in which direction you want to go. The charter company is being paid for the use of the plane and pilot. If a second or third look is required, have the pilot circle so that a more positive identification can be made. The pilot knows the limitations of the aircraft and flight conditions. He will let the observer know if the request is not safe or possible.

Photo 3 - Mapping aquatic vegetation from the back seat of Cessna 210.

Aerial visual monitoring is an efficient way for aquatic plant managers to keep current on field conditions over a large area in a small amount of time. □

AQUA-VINE

This year's annual FAPMS meeting will be held in Plant City, Fla. during the week of October 10-14, 1983. The exact dates will be finalized during the next Board of Directors meeting April 20, 1983 at Asgrow Fla. Co. in Plant City.

*****

Mr. Herb Cummings was selected by the Board of Directors to serve on the Aquatic Plant Advisory Council. Herb will succeed Mr. Les Bitting who will continue as an alternate delegate. The Society greatly appreciated Les Bitting's contribution to this advisory council. The next scheduled meeting is April 7 at 8:30 am. It will be held in Tallahassee at the Department of Natural Resources. All interested persons are encouraged to attend.

*****

In accordance with the changes on Chapter 487 in reference to pesticide applicator certification, many public licenses will require re-certification by May 31, 1983. Some commercial licenses will expire October 31, 1983. The license will cost $5 for the core plus one category. A five dollar fee will be required for a license in each additional category. These licenses will be valid for four years at which time re-certification will be required. Testing dates will be announced through various newsletters. For information on re-certification in aquatics contact:

Dr. Vernon V. Vandiver
3205 S. W. 70th Ave.
Davie, Florida 33317
305-475-8990

*****

"FLORIDA AQUATIC NAMES VICE PRESIDENT"

FT. LAUDERDALE, FLORIDA — William E. Lloyd has been named Vice President of Florida Aquatic Weed Control, Inc. He will supervise the company's marketing activities carried out through its four regional offices in Ft. Lauderdale, Ft. Myers, Tampa, and Daytona Beach. He formerly served as President of Lakes and Waterways Management Service, Inc. of Pompano Beach, Florida.

DNR — New Research Priorities

At its January 4, 1983, meeting the Florida Aquatic Plant Advisory Council adopted a new list of research priorities. The topics were divided into two groups, those with short objectives and those with long term objectives. The long term topics are:

- Criteria for defining an aquatic plant problem
- Documentation of treatment impacts
- Relative value and importance of aquatic plants
- Re-establishment of aquatic plants
- Baseline physiology of problem aquatic plants
- Development of tools to evaluate aquatic plant management options.

No order of priority was assigned to the long term topics. The short term topics in order of priority are:

1. Grass carp sterilization techniques
2. Aquatic plant control in flowing waters
3. Sonar application methodology
4. Effect of Diuron on aquatic floria and fauna
5. Control of *Eleocharis, Bacopa, Limnophila,* and *Hygrophila.*
6. Efficacy of hybrid grass carp

The Council recommended that the Department utilize a portion of its research budget to support long term research goals so that these important topics are not overlooked in favor of research with more immediate results.

The Department of Natural Resources has requested an increase in its research budget to $400,000 for the 1983-84 fiscal year. The Department expects to be issuing requests for proposals on these topics during March. Investigators who wish to be assured of receiving this request should write to: Larry Nall, Research Section Administrator, Bureau of Aquatic Plant Research and Control, Tallahassee, Florida 32303.

Personnel Changes at DNR

Mr. Greg Jubinsky, the South Florida regional biologist, has accepted a position in the Tallahassee office. Greg will be the Senior Biologist primarily in charge of the state aquatic plant control funding program which operates under the rules of Chapter 16C-5,0, F.A.C. Mr. Dan Thayer has assumed the South Florida regional biologist position. Dan is a recent master's graduate from the University of Florida. Dan was a student of Dr. Bill Haller at the Center for Aquatic Weeds.

The 1982 Aquatic Plant Survey Report is available from the Dept. of Natural Resources. Write: Bureau of Aquatic Plant Research and Control, 3900 Commonwealth Blvd. Tallahassee, Fla. 32302 or call 904-488-5631

Position Vacancy:
The Fla. Dept. of Agriculture and Consumer Services has a position vacancy in its Pesticide Enforcement section. This Specialist III position is to be located in the Delray Beach area. For additional information contact Mr. Bruce Miller, Division of Inspection, Tallahassee, Fla. 904-488-3314

South Florida Water Management District:
Gordon Baker, Weed Management Coordinator, announces that Lloyd Chesney has assumed the position of Assistant Weed Management Coordinator. John Cook, who formerly occupied this position has transferred to the electrical section within the District. □

Call For Papers

It's that time again. Time to become involved and participate in the 1983 FAPMS meeting in Plant City, Fla. Let the entire aquatic community know what you've been up to. Send in your paper title early to make certain of a slot on the program. Mail To:

Mrs. Deanna Brown
10307 South Indian River Dr.
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