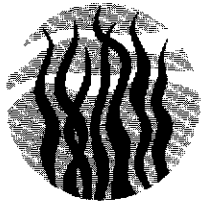


A Q U A P H Y T E



UNIVERSITY OF FLORIDA
CENTER FOR AQUATIC PLANTS
INSTITUTE OF FOOD AND AGRICULTURAL SCIENCES



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Exotic Fern A Threat to Wetlands

Yet another potentially serious exotic weed is spreading throughout the southeastern U.S. Although cultivated for its attractive soft green foliage, the Japanese Climbing Fern (*Lygodium japonicum*) is beginning to be seen as a threat to the native vegetation of shady wetlands such as floodplain forests.

The threat may be most real in South Florida, where year-round temperatures enable the naturalized plant to keep on growing, and growing, and growing...

The resulting tangled canopy of six-to-one hundred-foot-long fronds of the fern can be so dense that plants underneath them die for lack of sunlight.

This Asian exotic first appeared in North Carolina around 1900, and since has become naturalized south to Florida and west to Texas.

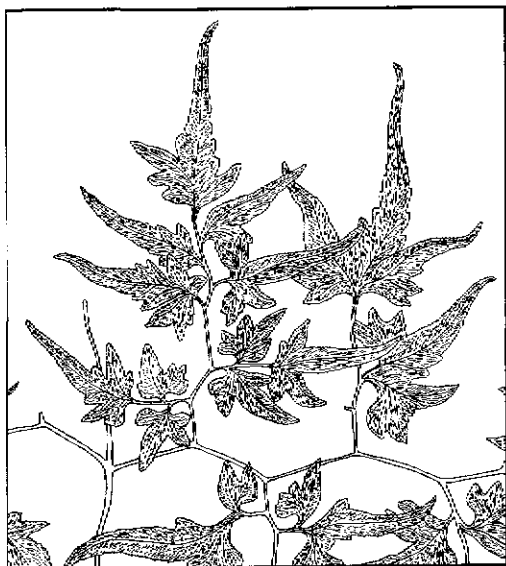


Illustration by Raphael Chiren Gottlieb

For an informative flyer, contact the APIRS office, address on page 16.

2 x CO₂ = X Aquatic Plants

Since the beginning of the industrial age, atmospheric carbon dioxide (CO₂) has increased by 25% to the current level of about 350 parts per million. Fuel combustion and deforestation are considered major contributors to this increase. Experts believe that CO₂ concentrations around the world will double by the end of the 21st century.

What will be the effects of increased carbon dioxide on plants? Will there be a "CO₂ fertilization effect" that makes plants grow larger and faster? Will increased CO₂ be a boon to agriculture? What will be the effects on unmanaged wild plants? Will certain plants make better use of the elevated CO₂ and replace other plants, thereby reducing biological diversity? How will animals react to the plant changes? Scientists are working to find answers to these questions, answers that might be used in predictive models that may help us plan for the coming changes.

The positive effects of increased CO₂ on plant growth have been known for the past two centuries. Photosynthesis is one of the most studied of natural phenomena. However, until the "greenhouse effect" controversy, little work had been devoted to the effects of elevated levels of CO₂ on plants. Now, many researchers are studying the effects of increased CO₂ on many parts of the environment, including aquatic plants.

One of the first major calls for work on elevated CO₂ and aquatic plants came in 1983 when R.G. Wetzel, J.B. Grace and a panel of other scientists reviewed the research and found it wanting. They recommended that programs be started to study the long-term effects of CO₂ enrichment; the mechanisms of C and O₂ supply and plant adaptations; nitrogen fixation; nutrient sequestering; noxious byproducts; and litter production and how it affects growth and plant population change.

A search of the APIRS aquatic plant database reveals that during the past ten years, a few dozen studies have been published about aquatic plant responses to elevated CO₂ levels. Listed below are some of them. (Many more studies about effects of elevated CO₂ on terrestrial plants have been published.) In addition, more than 500 studies are in the APIRS database about how aquatic plants actually use carbon sources (such as carbon dioxide) for photosynthesis.

Aquatic Plant Research

The following researchers have found a variety of responses of aquatic plants to elevated CO₂ levels in the air and water. It appears that, generally, a doubling of atmospheric CO₂ concentrations increases plant growth by approximately 30%. However, elevated CO₂ effects depend on a plant's photosynthetic pathway as well as on the interactive effects of light intensity, temperature, pH, oxygen concentration, nutrient availability, salinity and possibly other factors such as starch accumulation and plant shoot architecture. In the words of one researcher (Idso), "predicting the ultimate biospheric consequences of a doubling of the earth's atmospheric CO₂ concentration may prove to be much more complex than originally anticipated."

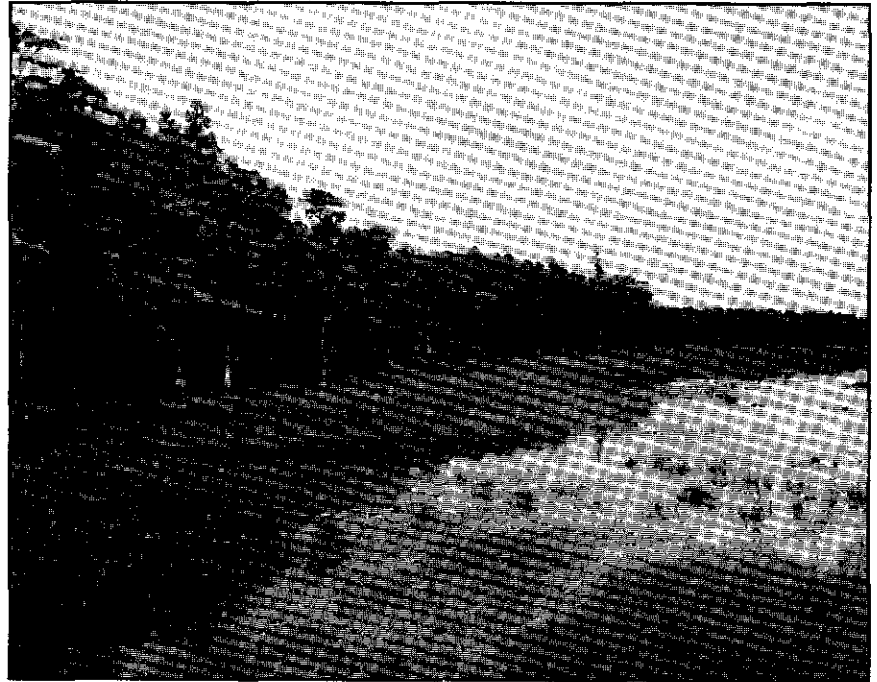
[See CO₂ on page 12]

Study This!

AQUATIC MACROPHYTES AND THEIR RELATION TO THE LIMNOLOGY OF FLORIDA LAKES by D.E. Canfield and M.V. Hoyer. 1992. 609 pages.

"Lakes in Florida are important resources and they often must be managed for a variety of purposes including flood control, water supply, fishing and general recreation. Lake usage, however, is a match between people's desires and the lake's capacity to satisfy these desires. Lake problems are defined in terms of the limits on desired uses. Many limitations can be prevented or corrected with proper lake management, but desired uses need to be clearly defined, limitations on the uses identified, and the causes understood."

The purpose of this study was to determine how aquatic plant management plans may affect water quality, fish populations and bird populations in Florida lakes. The five year study included 60 lakes of varying trophic states, size, depth and aquatic plant coverage.



Among the significant findings are:

- consistent with previous studies, total fish biomass increased as the lakes increased in trophic status; fish ranged from 6 kg/ha (5 pounds/acre) in an oligotrophic lake to 675 kg/ha (602 pounds/acre) in a hypereutrophic lake.
- fish populations are likely to be depressed when there are either too many or too few aquatic macrophytes.
- harvestable fish and sportfish populations in lakes having no aquatic macrophytes due to grass carp, showed no consistent trends. Thus long-term loss of macrophytes will not necessarily decrease the lake's fish populations.
- as in fish populations, bird abundance increased as the lake's trophic state increased.
- in a turbid nutrient-rich lake with no aquatic plant coverage, the cover must be raised to 30% to 50% before significant improvements in water clarity (chlorophyll *a* concentrations) will be observable. Conversely, significantly *reducing* macrophyte coverage of a lake, for example from 60% to 20% or from 40% to 0%, will cause significant and observable water quality (water clarity) changes.
- leaving a small fringe of vegetation around a lake for the purpose of water quality improvement will have little or no effect on the lake's trophic state values (total phosphorus, total nitrogen, chlorophyll *a*, algal levels and Secchi transparency).

With these findings in mind, the scientists suggest that a moderate amount of aquatic macrophytes would be beneficial to most Florida lakes. To preclude fisheries problems, a reasonable management objective for most Florida lakes may be a macrophyte coverage of at least 15% including emergent, floating-leaved and submersed vegetation.

Objectives such as this require a long-term commitment to some level of aquatic plant management. The authors also recommend "maintenance control" of non-native species such as hydrilla and water hyacinths so as not to allow these plants to completely take over lakes and replace native species.

The authors complete the study by recommending future research thrusts: develop better biocontrol techniques; develop species-specific aquatic plant management methods; find a method to remove grass carp after their work is done; find the environmental ranges of individual aquatic plant species; ascertain the relationships between water chemistry, lake morphology and macrophyte species composition; identify the management objectives for each lake; and develop better education for the general public about how lakes function, the values of macrophytes, and the risks and benefits of the various management methods.

A limited number of copies of this report are available from M.V. Hoyer, Department of Fisheries and Aquaculture, Center for Aquatic Plants, University of Florida, 7922 N.W. 71st Street, Gainesville, FL 32606, (904) 392-9617.

A T T H E C E N T E R

FISH AND HERBICIDES



How do largemouth bass react when the waterhyacinths they live around are sprayed with the herbicide 2,4-D? New graduate student Marvin Boyer hopes to address this controversy in aquatic plant management while gaining his master's degree. Working under Dr. Chuck Cichra (Fisheries and Aquaculture) and Dr. Bill Haller, Boyer comes to Gainesville from the University of Wisconsin, Stevens Point.

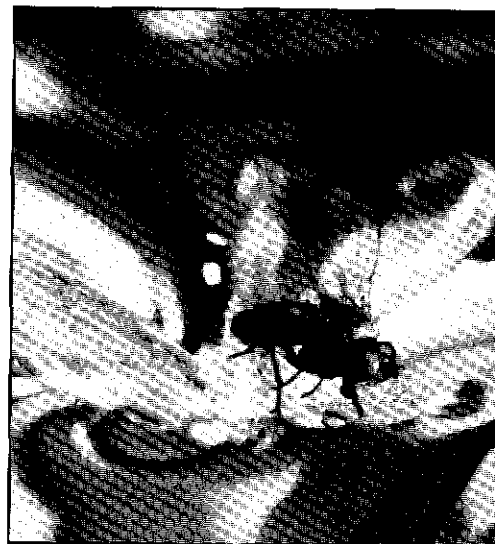
Will largemouth bass abandon a home range when their vegetation cover drops out or will they stay to take advantage of prey species left without host plants? What will they do if oxygen levels drop as plants decompose? Does a repellent component in the herbicide induce them to move or do airboats simply get on their nerves? Does spraying herbicides affect their behavior during the spawning season, affecting reproduction?

Tank studies will be used to determine if feeding habits are affected by the presence of 2,4-D in the water. In field studies, Boyer will capture and radio-tag largemouth bass this fall when cooler water temperatures will lessen the dangers of mortality to the fish. They will be released and monitored throughout the winter to determine their home ranges. After this phase is complete, experiments will monitor the reactions of the bass to herbicide spraying and vegetation loss. Possible study sites include Lake Rousseau and Bivens Arm in Florida.

Research Review Review

The Center's annual aquatic plant research review on March 31 once again drew dozens of scientists of all disciplines to share their latest data.

Among them were USDA's Dr. Ted Center who reported on hydrilla biocontrol efforts in Florida. According to Center, several ponds full of hydrilla have "dropped out" within months of introducing the aquatic fly *Hydrellia pakistanae* (right). Center says his group "can't really say the insects did it" yet, but the coincidences are piling up, and so are their fly establishment and monitoring efforts.



In another talk, Dr. D.F. Martin (Univ. South Florida) reported having isolated a possible fungus (a "white filamentous material") that may be preventing hydrilla from growing in a certain lake near Tampa. He hypothesizes that whatever is stifling the hydrilla is somehow connected to whatever decomposed the tons of cypress logging residues that were dumped into the same lake decades ago.

In their hydrilla physiology research, Drs. Mark Rattray and George Bowes (Univ. Florida) reported that for the first time, AHAS has been extracted from hydrilla. AHAS (acetoxy acid synthase) is a key enzyme in the biosynthesis of amino acids essential for growth. Their studies with "Mariner" herbicide indicate that the herbicide's mode of action against hydrilla is to quickly and greatly inhibit AHAS activity.

Other researchers presented talks about aquatic plant clone culturing, surveys of invertebrates on aquatic plants, aquatic herbicide research, grass carp studies and the economics of aquatic plant management.

CENTER FOR AQUATIC PLANTS
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Dr. Joseph Joyce, Director

Aquatic Plant Growers - Information Update

Those ubiquitous aquatic plants. If you are an aquatic plant manager, researcher, cultivator, extension agent or information specialist, you probably feel like you work in a rather remote field. But wherever you go, you see them in one form or another. *Nelumbo* seed pods in dried flower arrangements, talcum powders from wet-meadow plants, vitamin supplements from dried *Lyngbya*, lip balm from *Melaleuca alterniflora* oil, *Sphagnum* in 'feminine products', candles in the shape of *Nymphaea*, *Nymphaea* Eau de Parfum (at \$30.00 per bottle, according to the ad "a woman sprays it only where she wants to be kissed. . ."), *Ranunculus* on tea towels, *Trapa* in Asian food markets, *Typha* everywhere, and of course, aquariums and ornamental ponds.

According to the Florida Department of Agriculture and Consumer Services (FDACS), Florida's aquatic plant industry sold \$7 million worth of aquatic plants in 1989. To assist people in this industry, FDACS recently published the *Florida Aquatic Plant Locator*. The book lists retail and wholesale suppliers of plants for aquariums, ponds, food, and wetland restoration and mitigation. The book includes listings of exporters, installation and maintenance services, landscape architects, production and technical information, trade associations and regulatory agencies.

The *Florida Aquatic Plant Locator* is \$3.50, payable to FDACS. FDACS, Aquaculture Program, Room 425, Mayo Building, Tallahassee, FL 32399-0800, (904) 488-4033.

ABSORBENCY ONLY NATURE COULD PROVIDE.

For the core of our protection, we went to a very reliable source. Nature. We've tapped into one of Earth's most powerful absorbents. It's called Sphagnum.



This unique plant grows in the cold, clean waters of Canada where we harvest it. Purify it. Then compress it into an ultra thin layer possessing superior absorbent abilities.

Mags and Orgs

The Aquatic Gardener is the journal of the Aquatic Gardeners Association, whose stated purpose is to disseminate information about, to study and improve culture techniques for, and to increase interest in, aquatic plants. Mostly comprised of articles from members, the journal focuses on practical information about growing aquarium plants for the hobbyist. The Technical Advisory Committee of the association offers a question and answer section in the bi-monthly journal.

The Aquatic Gardeners Association, 83 Cathcart Street, London, Ontario, N6C 3L9, CANADA. Membership, \$15.00 yearly in N. America, \$28.00 overseas.

The National Pond Society is "dedicated to helping people to be successful pond keepers at home, in community groups and in institutions because we believe 'pondering' adds joy to living while improving the environment and encouraging an appreciation of the earth."

Pondscapes is the society's monthly magazine, and is written "for and by pond keepers". It is packed with information. A recent issue contained articles about pond fish, dissolved oxygen, building waterfalls, growing water lilies, drying water lilies, and tips for planning and building water gardens. The December issue contains a national directory of suppliers of pond products and services and lists volunteers in over twenty-five states who are willing to field questions on water gardening.


Upcoming events of the Society include the Atlanta Tour of Ponds and the American Pond and Garden Expo in June 1992. The group has many interesting ideas and projects, such as starting a pond keepers youth group, wildlife habitat pond projects for grammar schools, and volunteering labor for special groups such as the Atlanta Zoo and the Jewish Nursing Home's therapeutic gardening service.

The National Pond Society, P.O. Box 449, Acworth, GA 30101, (404) 975-0277. Membership, \$18.00 yearly domestic, \$36.00 foreign and commercial.

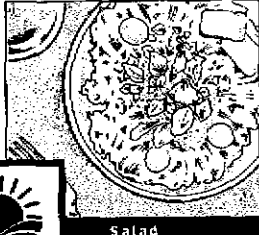
FLORIDA

Aquatic Plant Locator


A listing of sources of Florida Aquatic Plants
for the aquarium, garden pool, restoration project or salad



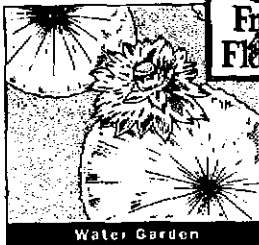
Aquarium




Salad



Fresh Florida



Water Garden



Mitigation/Restoration

Florida Department of Agriculture and Consumer Services
BOB CRAWFORD, Commissioner

BOOKS/REPORTS

ATTRIBUTES OF WISCONSIN LAKE PLANTS by S.A. Nichols and J.G. Vennie, Wisconsin Geological and Natural History Survey. 1991. 19 pages.

(Order from University of Wisconsin - Extension, Geological and Natural History Survey, Map and Publications Office, 3817 Mineral Point Road, Madison, Wisconsin 53705, 608/263-7389. Information Circular 73. \$3.00 plus \$1.50 postage.)

Published for aquatic plant managers, this deceptively thin circular includes more practical information about aquatic plants than many publications 10 times its size. It is meant to help managers "to know which species are desirable and how to encourage them as well as which species are likely to be nuisances and how to discourage them."

This collection of five simple "attribute tables" of 149 aquatic plants lists the plants, their habitat preference, wildlife and environmental value, propagation method, and herbicide susceptibility.

The book is very easy to use and understand: managers, students and other users will be surprised by how much they can learn from simple tables.

BIOLOGICAL CONTROL OF WEEDS - A HANDBOOK FOR PRACTITIONERS AND STUDENTS by K.L.S. Harley and I.W. Forno, CSIRO, Australia. 1992. 88 pages.

(Order from Butterworth-Heinemann, 271-273 Lane Cove Road, P.O. Box 345, North Ryde, N.S.W. 2113, AUSTRALIA. Aud\$39.95.)

Written by two of the foremost experts in the subject, this book is a concise treatment of the background and procedures involved in the use of the biological method of controlling weeds. It would be useful to anyone interested in the subject, from students to experienced scientists.

The book discusses all aspects of a biological control project including the selection of the target weed; finding effective control agents; ensuring that the agents are host-specific and free of diseases and parasites; and the rearing, distribution and monitoring of biological agents. It also contains

chapters on the history of classical biological control. Also included is an appendix outlining the design and operation of insect reception and quarantine facilities.

CONSERVATION GUIDELINES FOR ASSESSING THE POTENTIAL IMPACTS OF WASTEWATER DISCHARGES TO WETLANDS by J.G.

Cooke, Water Quality Centre, DSIR, New Zealand. 1991. 49 pages.

(Order from Water Quality Centre, DSIR Division of Water Sciences, P.O. Box 11-115, Hamilton, NEW ZEALAND.)

According to the author, the concept of using New Zealand wetlands for disposal of wastewaters has become increasingly popular for two reasons: 1) "it is extremely cost-effective" and 2) "...there is increasing understanding of the Maori perspective on waste disposal, which opposes direct discharge of sewage into natural waters because it is an affront to its wairua and therefore affects the mana of those who use it."

This report is for conservation officers who are responsible for evaluating applications to discharge wastewater into wetlands. It includes a review of the ecological impacts of wastewaters on wetlands and presents guidelines for assessing waste discharge proposals.

THE ECOLOGY OF TROPICAL LAKES AND RIVERS by A.I. Payne,

Coventry Polytechnic. 1986. 301 pages. (Order from John Wiley & Sons, Inc, 1 Wiley Drive, Somerset, New Jersey 08875-1272, 201/469-4400. \$84.95 cloth.)

This "self-contained textbook for students from tropical countries" explains all important concepts of aquatic ecology in the tropics. The book includes chapters about river and lake environments including water chemistry, drainage basins and morphometry, hydrology, and stratification. Also included are chapters about the community structures and dynamics of plankton, benthic animals, and macrophytes, including text on primary productivity, nutrient cycling and secondary production. Seasons, phenology, and animal periodicity are discussed in one chapter; diversity and evolution are discussed in another.

The final chapter discusses aquaculture and fisheries management.

LIGHT CLIMATE AND ITS IMPACT ON POTAMOGETON PECTINATUS L. IN A SHALLOW EUTROPHIC LAKE by G.M. van Dijk. 1991. 125 pages.

The purpose of this book is to examine the effects of eutrophication and light on algal and vascular plant growth, abundance and succession. One general hypothesis could be described: increased nutrients in a lake cause algal populations to increase, thereby reducing light to submersed plants. The submersed plants die off, thus making even more nutrients available to algal populations.

The final part of this book is a discussion of lake restoration projects in The Netherlands. It includes an assessment of the potential of biomanipulation (using fish, sediment-management and macrophyte re-establishment) as a method to restore eutrophic lakes. The author concludes that water quality managers should pay more attention to submersed vegetation, which has positive and negative impacts on the functioning of shallow aquatic ecosystems.

ISOZYMES IN WATER PLANTS, Opera Botanica Belgica 4, edited by L. Triest. 1991. 264 pages.

(Order from Dr. R. Clarysse, National Botanic Garden of Belgium, Domein van Bouchout, B-1860 Meise, BELGIUM. 1600 BEF, plus 300 BEF for foreign checks.)

An "isozyme" (=isoenzyme) is a molecular form of an enzyme. Electrophoretic analysis of isozymes enable researchers to identify species, clones, races and populations. Among other benefits, such analysis of aquatic plants ultimately helps in working out appropriate control and management programs, especially for plants deemed "weeds".

This book is a review of the electrophoretic studies in aquatic macrophytes and algae. It includes information on the molecular systematics and biogeography of *Alisma*, *Baldellia*, *Hydrilla*, *Lagarosiphon*, *Potamogeton*, *Ruppia*, *Zannichellia*, *Najas* and the seagrasses.

FROM THE DATABASE

Here is a sampling of the research articles, books and reports which have been entered into the aquatic plant database since November, 1991.

The database has more than 33,000 items. To receive free bibliographies on specific plants and/or subjects, contact APIRS at the address shown on the mail label on page 16.

To obtain articles, contact your nearest state or university library.

Agusti, S.; Duarte, C.M.; Canfield, D.E.

Phytoplankton abundance in Florida lakes: evidence for the frequent lack of nutrient limitation.

LIMNOL. OCEANOGR. 35(1):181-188, 1990.

Alimi, T.; Akinyemiju, O.A.

Effects of waterhyacinth on water transportation in Nigeria.

J. AQUATIC PLANT MGMT. 29:109-112, 1991.

Anderson, L.W.J.; Perry, S.

Effects of triclopyr on *Ludwigia peploides* and *Myriophyllum spicatum*. IN: ANNUAL REPORT - 1990: AQUATIC WEED CONTROL INVESTIGATIONS, ANDERSON, L.W.J., RYAN, F.J. AND SPENCER, D.F., EDS., USDA, AGRIC. RES. SERV., BOT. DEPT., UNIV. OF CALIF., DAVIS, PP. 19-21, 1990.

Appenroth, K.J.; Hertel, W.; Augsten, H.

Photophysiology of turion germination in *Spirodela polyrhiza* (L.) Schleiden. The cause of germination inhibition by overcrowding.

BIOLOGIA PLANTARUM 32(6):420-428, 1990.

Archibold, O.W.; Reed, W.B.

Airboat design and operational losses of a wild rice harvester.

CAN. AGRIC. ENGN. 32:69-74, 1990.

Armora, J.P.R.G.

Flora acuatica vascular (monocotiledoneas) del Estado de Chiapas.

MASTER'S THESIS, UNIV. NACIONAL AUTONOMA DE MEXICO, COYOACAN, 113 pp., 1991. (In Spanish)

Austin, A.P.; Harris, G.E.; Lucey, W.P.

Impact of an organophosphate herbicide (glyphosate) on periphyton communities developed in experimental streams.

BULL. ENVIRON. CONTAM. TOXICOL. 47:29-35, 1991.

Beer, S.; Sand-Jensen, K.; Madsen, T.V.; Nielsen, S.L.

The carboxylase activity of Rubisco and the photosynthetic performance in aquatic plants.

OECOLOGIA 87:429-434, 1991.

Bettoli, P.W.; Morris, J.E.; Noble, R.L.

Changes in the abundance of two atherinid species after aquatic vegetation removal.

TRANS. AMER. FISH. SOC. 120:90-97, 1991.

Bowerman, L.; Goos, R.D.

Fungi associated with living leaves of *Nymphaea odorata*.

MYCOLOGIA 83(4):513-516, 1991.

Carter, V.; Rybicki, N.B.; Hammerschlag, R.

Effects of submersed macrophytes on dissolved oxygen, pH, and temperature under different conditions of wind, tide, and bed structure.

J. FRESHWATER ECOL. 6(2):121-133, 1991.

Cevallos-Ferriz, S.R.S.; Stuckey, R.A.; Pigg, K.B.

The Princeton chert: evidence for *in situ* aquatic plants.

REVIEW PALAEOBOT. PALYNOL. 70:173-185, 1991.

Chambers, P.A.; Hanson, J.M.; Prepas, E.E.

The effect of aquatic plant chemistry and morphology on feeding selectivity by the crayfish, *Orconectes virilis*.

FRESHWATER BIOL. 25:339-348, 1991.

Chand, T.; Lembi, C.A.

Gas chromatographic determination of flurprimidol in a submersed aquatic plant (*Myriophyllum spicatum*), soil, and water.

J. PLANT GROWTH REGUL. 10:73-78, 1991.

Chergui, H.; Pattee, E.

The processing of leaves of trees and aquatic macrophytes in the network of the River Rhone.

INT. REVUE GES. HYDROBIOL. 75(3):281-302, 1990.

Cooke, J.G.; Cooper, A.B.; Clunie, N.M.U.

Changes in the water, soil, and vegetation of a wetland after a decade of receiving a sewage effluent.

NEW ZEALAND J. ECOL. 14:37-47, 1990.

Coops, H.; Boeters, R.; Smit, H.

Direct and indirect effects of wave attack on helophytes.

AQUATIC BOT. 41:333-352, 1991.

Counts, R.L.; Lee, P.F.

Germination and early seedling growth in some northern wild rice (*Zizania palustris*) populations differing in seed size.

CAN. J. BOT. 69:689-696, 1991.

Coutinho, M.E.

Ecologia populacional de *Eichhornia azurea* (Kth.) e sua participacao na dinamica da vegetacao aquatica da Lagoa do Infernao - SP.

DISSERTACAO DE MESTRADO, UNIVERSIDADE FEDERAL DE SAO CARLOS, UFSCAR, BRASIL. 145 PP. (In Portuguese)

Crowder, A.

Acidification, metals and macrophytes.

ENVIRON. POLLUTION 71:171-203, 1991.

Daldorph, P.W.G.; Thomas, J.D.

The effect of nutrient enrichment on a freshwater community dominated by macrophytes and molluscs and its relevance to snail control.

J. APPL. ECOL. 28:685-702, 1991.

Davis, S.M.

Growth, decomposition, and nutrient retention of *Cladium jamaicense* Crantz and *Typha domingensis* Pers. in the Florida Everglades.

AQUATIC BOT. 40:203-224, 1991.

De Casabianca-Chassany, M.L.; Goma, G.

Treatment of paper industry effluents with *Eichhornia crassipes*: first results (Tartas factory, Landes).

C.R. ACAD. SCI. 312(SERIE III): 579-585, 1991. (In French; English Summary)

Dionne, M.; Folt, C.L.

An experimental analysis of macrophyte growth forms as fish foraging habitat.

CAN. J. FISH. AQUAT. SCI. 48:123-131, 1991.

Ewing, K.

Plant growth and productivity along complex gradients in a Pacific Northwest brackish intertidal marsh.

ESTUARIES 9(1):49-62, 1986.

Fagerberg, W.R.; Eighmy, T.T.; Jahnke, L.S.

Studies of *Elodea nuttallii* grown under photorespiratory conditions. III. Quantitative cytological characteristics.

PLANT CELL ENVIRON. 14:167-173, 1991.

Felle, H.H.

The role of the plasma membrane proton pump in short-term pH regulation in the aquatic liverwort *Riccia fluitans* L.

J. EXPER. BOT. 42(238):645-652, 1991.

Friday, L.E.

The size and shape of traps of *Utricularia vulgaris* L.

FUNCTIONAL ECOL. 5:602-607, 1991.

Gadzhev, V.D.; Lyatifova, A.K.

Samples of wet-marsh vegetation of Kyzylgash (Kazakhstan) Soviet Preserves.

J. AZERBAIJAN ACAD. SCI. 2:3-9, 1988. (In Russian)

Gauthier, G.; Bedard, J.

Experimental tests of the palatability of forage plants in greater snow geese.

J. APPL. ECOL. 28:491-500, 1991.

Gobas, F.A.P.C.; McNeil, E.J.; Lovett-Doust, L.; Haffner, G.D.

Bioconcentration of chlorinated aromatic hydrocarbons in aquatic macrophytes.

ENVIRON. SCI. TECHNOL. 25(5):924-929, 1991.

Haworth-Brockman, M.J.; Murkin, H.R.; Clay, R.T.; Armson, E.

Effects of underwater clipping of purple loosestrife in a southern Ontario wetland.

J. AQUATIC PLANT MGMT. 29:117-118, 1991.

Horecka, M.

The significant role of *Chara hispida* - grown in water regime of a gravel pit lake at Senec.

ARCH. PROTISTENK. 139:275-278, 1991.

Husband, B.C.; Barrett, S.C.H.

Colonization history and population genetic structure of *Eichhornia paniculata* in Jamaica.

HEREDITY 66:287-296, 1991.

Kantrud, H.A.

Wigeongrass (*Ruppia maritima* L.): a literature review.

U.S. FISH WILDL. SERV., FISH WILDL. RES. 10. 58 PP. 1991.

Kouki, J.

Small-scale distributional dynamics of the yellow water-lily and its herbivore *Galerucella nymphaeae* (Coleoptera: Chrysomelidae).

OECOLOGIA 88:48-54, 1991.

Kruger, L.; Kirst, G.O.

Field studies on the ecology of *Bolboschoenus maritimus* (L.) Palla (*Scirpus maritimus* L. S. L.).

FOLIA GEOBOT. PHYTOTAX. 26(3):277-286, 1991.

Kulmi, G.S.

Associated weed flora and their susceptibility to herbicides in transplanted rice.

INDIAN J. AGRON. 36(1):113-116, 1991.

Lagarde, F.; Gauthier, M.

Heteranthera limosa (Sw.) Willd. (Pontederiaceae) en France.

BULL. SOC. BOT. FR. 138(3):239-240, 1991. (In French; English Summary)

Latham, P.J.; Pearlstine, L.G.; Kitchens, W.M.

Spatial distributions of the softstem bulrush, *Scirpus validus*, across a salinity gradient.

ESTUARIES 14(2):192-198, 1991.

Leach, S.J.; McMullin, A.S.; Northridge, R.H.

Rhynchospora fusca (L.) Alt. F. in Co Fermanagh.

IRISH NAT. J. 22(6):262., 1987.

Lee, C.K.; Low, K.S.; Hew, N.S.

Accumulation of arsenic by aquatic plants.

SCI. TOTAL ENVIRON. 103:215-227, 1991.

Les, D.H.

Genetic diversity in the monoecious hydrophile *Ceratophyllum*.

AMER. J. BOT. 78(8):1070-1082, 1991.

Lindau, C.W.; Delaune, R.D.; Jiraporncharoen, S.; Manajuti, D.

Nitrous oxide and dinitrogen emissions from *Panicum hemitomon* S. freshwater marsh soils following addition of N-15 labelled ammonium and nitrate.

J. FRESHWATER ECOL. 6(2):191-198, 1991

Linz, G.M.; Davis, J.E.; Engeman, R.M.; et al.

Estimating survival of bird carcasses in cattail marshes.

WILDL. SOC. BULL. 19:195-199, 1991.

Lopez, J.; Carballeira, A.; Barreiro, R.; Real, C.

Relation between pigmentary stress in *Fontinalis antipyretica* Hedw. and metal pollution in Galician (N.W. Spain) rivers.

HEAVY METALS ENVIRON. 2:172-175, 1991.

Lund, M.; Davis, J.; Murray, F.

The fate of lead from duck shooting and road runoff in three western Australian wetlands.

AUST. J. MAR. FRESHWATER RES. 42:139-149, 1991.

Madamwar, D.; Patel, A.; Patel, V.

Effects of various surfactants on anaerobic digestion of water hyacinth-cattle dung.

BIORESOURCE TECHNOL. 37:157-160, 1991.

Madsen, J.D.; Sutherland, J.W.; Bloomfield, J.A.; et al.

The decline of native vegetation under dense Eurasian watermilfoil canopies.

J. AQUATIC PLANT MGMT. 29:94-99, 1991.

Madsen, T.V.

Inorganic carbon uptake kinetics of the stream macrophyte *Callitriche cophocarpa* Sendt.

AQUATIC BOT. 40:321-332, 1991.

Mandal, B.K.; Das, N.C.; Singh, Y.V.; Ghosh, R.K.

Effect of phosphorus on multiplication and nitrogen content of *Azolla pin-nata*.

INDIAN J. AGRIC. SCI. 61(2):128-130, 1991.

Menapace, F.J.

A preliminary micromorphological analysis of *Eleocharis* (Cyperaceae) achenes for systematic potential.
CAN. J. BOT. 69:1533-1541, 1991.

Merendino, M.T.; Smith, L.M.

Influence of drawdown date and reflood depth on wetland vegetation establishment.
WILDL. SOC. BULL. 19:143-150, 1991.

Mytinger, L.; Williamson, G.B.

The invasion of *Schinus* into saline communities of Everglades National Park.
FLORIDA SCIENTIST 50(1):7-12, 1987.

Newman, R.M.

Herbivory and detritivory on freshwater macrophytes by invertebrates: a review.
J. N. AMER. BENTHOL. SOC. 10(2):89-114, 1991.

Nielsen, S.L.; Gacia, E.; Sand-Jensen, K.

Land plants of amphibious *Littorella uniflora* (L.) Aschers. maintain utilization of CO₂ from the sediment.
OECOLOGIA 88:258-262, 1991.

Niklas, K.J.

Bending stiffness of cylindrical plant organs with a 'core-rind' construction: evidence from *Juncus effusus* leaves.
AMER. J. BOT. 78(4):561-568, 1991.

Olsen, T.M.; Lodge, D.M.; Capelli, G.M.; Houlihan, R.J.

Mechanisms of impact of an introduced crayfish (*Orconectes rusticus*) on littoral congeners, snails, and macrophytes.
CAN. J. FISH AQUAT. SCI. 48:1853-1861, 1991.

Osborn, J.M.; Taylor, T.N.; Schneider, E.L.

Pollen morphology and ultrastructure of the Cabombaceae: correlations with pollination biology.
AMER. J. BOT. 78(10):1367-1378, 1991.

Outridge, P.M.; Noller, B.N.

Accumulation of toxic trace elements by freshwater vascular plants.
REVIEWS ENVIRON. CONTAM. TOXICOL. 121:1-63, 1991.

Overath, R.B.; Titus, J.E.; Hoover, J.E.; Grise, D.J.

The influence of field site and natural sediments on the growth and tissue chemistry of *Vallisneria americana* Michx.
J. FRESHWATER ECOL. 6(2):135-145, 1991.

Ozimek, T.; Pieczynska, E.; Hankiewicz, A.

Effects of filamentous algae on submerged macrophyte growth: a laboratory experiment.
AQUATIC BOT. 41:309-315, 1991.

Pandey, V.N.; Srivastava, A.K.

Yield and nutritional quality of leaf protein concentrate from *Eleocharis dulcis* (Burm. F.) Hensch.
AQUATIC BOT. 41:369-374, 1991.

Peerally, A.

Cylindrocladium hawksworthii sp. nov. pathogenic on water-lilies in Mauritius.
MYCOTAXON 40:367-376, 1991.

Petrell, R.J.; Bagnall, L.O.

Hydromechanical properties of water water hyacinth mats.
AQUACULTURAL ENGINEERING 10:133-147, 1991.

Pezeshki, S.R.; DeLaune, R.D.

A comparative study of above-ground productivity of dominant U.S. gulf coast marsh species.
J. VEGETATION SCI. 2:331-338, 1991.

Pine, R.T.; Anderson, L.W.J.

Effect of triploid grass carp on submerged aquatic plants in northern California ponds.
CALIF. FISH & GAME 77(1):27-35, 1991.

Poddar, K.; Mandal, L.; Banerjee, G.C.

Evaluation of nutritive value of water hyacinth in wilted and silage forms.
INDIAN J. ANIMAL SCI. 61(4):452-454, 1991.

Polar, E.; Bayulgen, N.

Differences in the availabilities of Cesium-134, 137 and Ruthenium-106 from a Chernobyl-contaminated soil to a water plant, duckweed, and to the terrestrial plants, bean and lettuce.
J. ENVIRON. RADIOACTIVITY 13:251-259, 1991.

Powell, G.V.N.; Fourqurean, J.W.; Kenworthy, W.J.; Zieman, J.C.

Bird colonies cause seagrass enrichment in a subtropical estuary: observational and experimental evidence.
ESTUARINE COASTAL SHELF SCI. 32:567-579, 1991.

Rattray, M.R.; Howard-Williams, C.; Brown, J.M.A.

Sediment and water as sources of nitrogen and phosphorus for submerged rooted aquatic macrophytes.
AQUATIC BOT. 40:225-237, 1991.

Reddy, K.R.; Agami, M.; D'Angelo, E.M.; Tucker, J.C.

Influence of potassium supply on growth and nutrient storage by water hyacinth.
BIORESOURCE TECHNOL. 37:79-84, 1991.

Robblee, M.B.; Barber, T.R.; Carlson, P.R.; et al.

Mass mortality of the tropical seagrass *Thalassia testudinum* in Florida Bay.
MAR. ECOL. PROG. SER. 71:297-299, 1991.

Rodriguez, E.M.; Amin, O.A.

Acute toxicity of parathion and 2,4-D to larval and juvenile stages of *Chasmagnathus granulata* (Decapoda, Brachyura).
BULL. ENVIRON. CONTAM. TOXICOL. 47:634-640, 1991.

Sawidis, T.; Stratis, J.; Zachariadis, G.

Distribution of heavy metals in sediments and aquatic plants of the River Pinios (Central Greece).
SCI. TOTAL ENVIRON. 102:261-266, 1991.

Schwegler, T.; Brandle, R.

Ethylene-dependent growth and development of cuttings of the water cress (*Nasturtium officinale* R. Br.).
BOT. HELVETICA 101(1):135-140, 1991. (In German; English Summary)

Servin, L.C.; Gutierrez, J.V.

Plantas medicinales del Distrito de Ocotlan Oaxaca.
ANALES INST. BIOL. UNIV. NAC. AUTON. SER. BOT. 60(1):85-103, 1990. (IN SPANISH; ENGLISH SUMMARY)

Sharp, M.J.; Britton, D.M.

Isoetes tuckermanii, Tuckerman's Quillwort, an addition to the flora of Ontario.