US Army Corps
of Engineers
Waterways Experiment
Station

Aquatic Plant Control Research Program

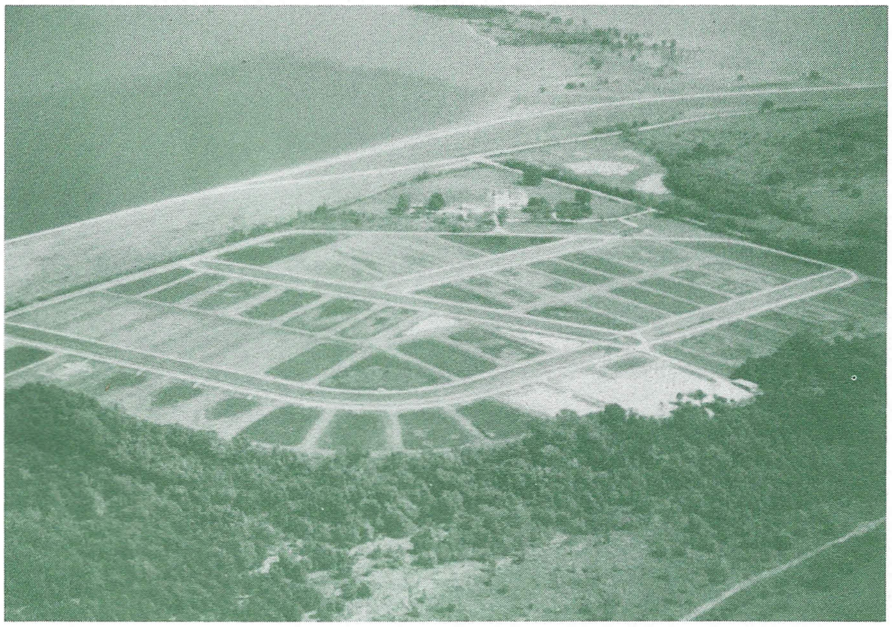
Vol A-94-1 January 1994

Aquatic plant research at Lewisville Aquatic Ecosystem Research Facility

by
R. Michael Smart and J. Lewis Decell

The U.S. Army Engineer Waterways Experiment Station (WES) operates the Lewisville Aquatic Ecosystem Research Facility (LAERF) in Lewisville, Texas, to provide an intermediate-scale research environment that bridges the gap between small-scale laboratory studies and large-scale field tests.

This experimental pond facility is being developed under the Corps of Engineers' Aquatic Plant Control Research Program (APCRP) to support studies of the biology, ecology, and management of aquatic plants.



Aerial view of pond facility (Lewisville Lake in background)

The LAERF includes 53 experimental ponds, a main office-laboratory building, a greenhouse equipped with 20 temperature-controlled experimental tanks, a 30-tank outdoor mesocosm system, additional outdoor tank systems for deep- and shallow-water studies, 18 flowing-water raceways, and several remote support labs. Collectively, these facilities provide opportunities for conducting aquatic plant research on a variety of temporal and spatial scales. This research is critical for developing the information base that is needed to solve the Corps' aquatic plant problems.

The LAERF is maintained and operated by a resident staff of Government employees and contractors, and the facilities are available to all WES scientists and engineers, to other Federal agencies, and to universities on a pay-as-you-use basis.

History

Built in the mid-1950s, the facility was operated by the Texas Parks and Wildlife Department (TPWD) as a fish hatchery until 1985. In 1988 the property, which is located immediately below the dam of Lewisville Lake, a Corps reservoir, was reacquired from the State of Texas by the Corps' Fort Worth District. That same year, WES signed an agreement with the District to use the facility for research for a 25-year, renewable period.

After several years of abandonment, the facility was badly in need of repairs. In 1989, the APCRP provided funds to begin renovation, and the District provided much-needed engineering and logistical support. Although renovation was far from complete, the facility officially opened as the Lewisville Aquatic Plant Research Facility on August 15, 1989. In recognition of the facility's potential for supporting a broader, more diverse research base in the future, the name was changed the following year to the Lewisville Aquatic Ecosystem Research Facility.

In 1991, the Corps established the Lewisville Lake Environmental Learning Area (LLELA). This tract of Corps land, slightly over 800 hectares surrounding the LAERF, was licensed to a consortium of six local universities and the Lewisville Independent School District for environmental preservation and restoration, environmental education, and research. Both the WES and the Fort Worth District are represented on the LLELA Consortium's Board of Directors, and LAERF personnel have been involved in activities of the consortium since its inception. The LAERF is expected to benefit from its association with the LLELA member universities and the variety of environmental activities that are attracted to the area.

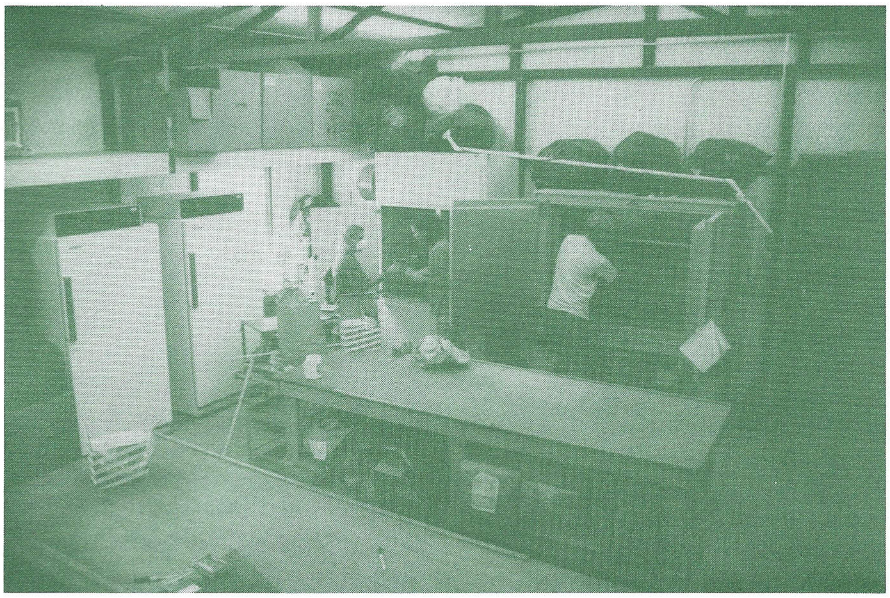
Analytical laboratory

An onsite analytical laboratory is equipped for processing and analyzing water, plant, and sediment samples. An ongoing water chemistry monitoring program provides investigators with information on experimental conditions occurring in the ponds, mesocosms, tanks, and raceways.

Water samples are routinely analyzed for standard limnological parameters such as alkalinity, dissolved inorganic carbon, turbidity, dissolved and suspended solids, nutrients, and metals.

Plant samples are routinely ashed to determine organic matter content, and are digested for analysis of nutrients and metals. Fresh

The well-equipped laboratory provides onsite analysis of plants, water, and sediments



The plant processing lab supports studies in ponds, mesocosms, and greenhouses

plant material is also frequently analyzed for chlorophyll content.

Sediment samples are analyzed for particle size; dried and combusted to determine moisture, density, and organic content; centrifuged to remove interstitial water for nutrient analysis; and extracted to determine plant-available nutrients and metals.

Water, plant, and sediment samples are also collected at various field sites and returned to the LAERF for analysis.

Additional analytical capabilities include instruments for routine or extended monitoring of water quality. Currently available are 14 datasondes (for continuous water quality monitoring); field sampling gear (integrated water samplers, close-interval samplers, plankton nets, sediment interstitial water (dialysis) samplers, sediment core samplers, and dredges); and several aquatic and terrestrial light sensors, meters, and dataloggers.

Plant processing and physiology laboratories

In addition to the analytical laboratory, other labs are equipped to support aquatic plant studies. A 56-square meter plant processing lab houses plant processing tables, sinks, refrigerators, and additional equipment for sample processing. Over 15 cubic meters of oven space is available for drying large volumes of aquatic plant samples. Electronic balances include both stationary laboratory and portable field models. Plant and soil grinding mills of various sizes are available to prepare plant samples for analysis.

The plant physiology laboratory is equipped with a controlled-environment photosynthesis system for measuring photosynthesis and respiration of submersed aquatic plants under different light, temperature, water chemistry, and flow conditions. This system is capable of providing continuous, simultaneous measurement of dissolved oxygen and pH for up to six photosynthesis chambers. Samples can also be withdrawn and analyzed for dissolved inorganic carbon. An infrared gas analyzer is available for measuring carbon dioxide concentrations in air.

The photosynthesis system is being used to evaluate the competitive ability of exotic and native species. The system will also be used in studies of the phenology of

Identifying critical points in the life cycle of waterhyacinth provides more effective control

exotic species of submersed aquatic plants.

A portable, automated photosynthesis system provides instantaneous rates of photosynthesis of aerial leaves, in either the laboratory or the field. This system has been used to study photosynthesis and respiration of the floating aquatic plant waterhyacinth.

Environmental monitoring

An onsite meteorological station collects environmental data to support studies conducted at the LAERF. Many of the experimental ponds have been equipped with additional sensors and datalogging equipment to obtain continuous records of water temperature and other environmental parameters needed for specific investigations.

Pond research

The 53 experimental ponds at the LAERF are excavated earthen ponds ranging from 0.2 to 0.8 hectare in size and up to 2 m in depth. The ponds are supplied with water from adjacent Lewisville Lake and can be filled and drained independently, allowing the investigator to control experimental hydrologic regimes. Many of the ponds are also fitted with adjustable standpipes to provide constant water levels if desired.

Biological control

Biological control of aquatic plants is being studied at the LAERF in evaluations of the efficacy of a microbial plant pathogen for controlling the growth of *Myriophyllum spicatum* (Eurasian watermilfoil) and *Hydrilla verticillata* (hydrilla). The biocontrol agent, a fungus named *Mycoleptodiscus terrestris* (*Mt* for short), has been demonstrated to kill both Eurasian watermilfoil and hydrilla in laboratory cultures. The current pond studies are evaluating the ability of *Mt* to control each of these plants on a larger scale.

Life cycle studies

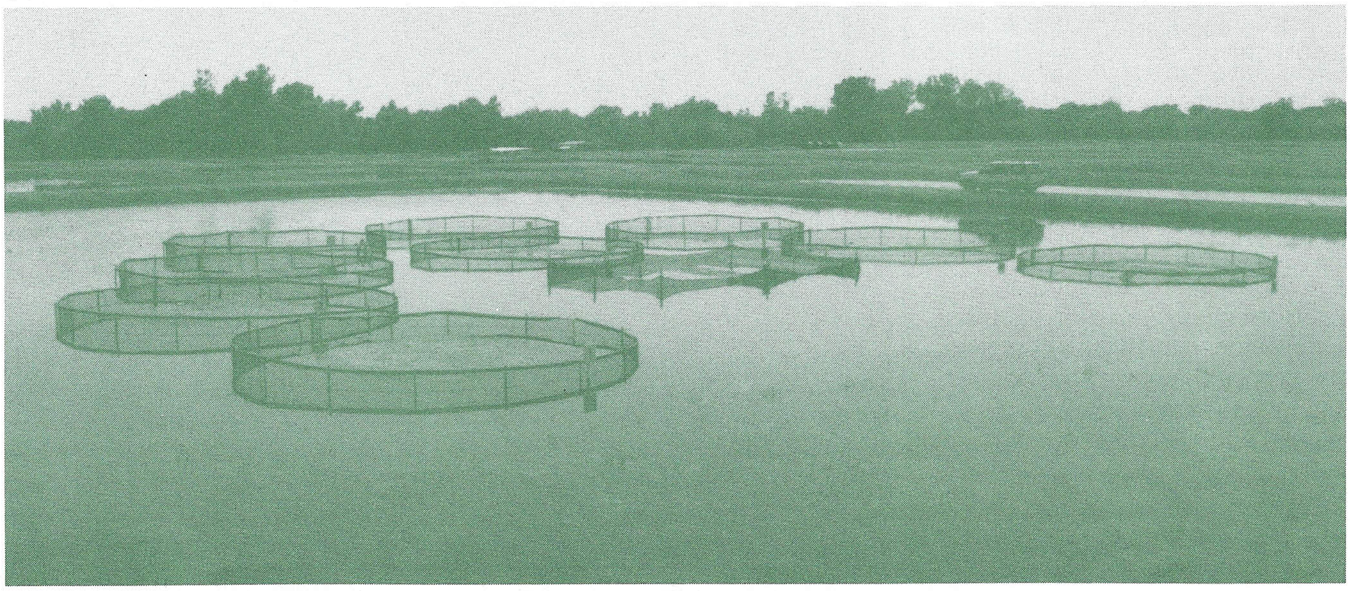
To achieve the most effective aquatic plant control technology, it is necessary to understand the life cycle (phenology) of the target plant species. The growth and seasonal development of waterhyacinth have been examined in LAERF pond studies that involve photosynthesis and respiration; biomass accumulation and allocation; nutrient uptake, allocation, and storage; and reproduction, both from seed and from stolons (runners). The more important factors influencing these processes—temperature, nutrient availability, and the degree of crowding—have also been studied.

These studies have identified critical points in the life cycle of waterhyacinth, when the plant would be most susceptible to the application of control technology. This information will allow managers to effectively control waterhyacinth with application of minimal quantities of herbicide.

A pond-scale demonstration of this technology refinement is currently under way at the LAERF. Similar studies of the biology and ecology of Eurasian watermilfoil are in progress, and future studies will include hydrilla.

Plant competition studies

A relatively new area of aquatic plant management involves the planting of competitive native species to resist the reinvasion of previously controlled areas by exotic problem species.



Enclosures in an experimental pond allow investigators to study the effects of aquatic plants on fish populations

Greenhouse research conducted at LAERF has identified several desirable native plants that are both beneficial to the environment and may have the competitive ability needed to resist invasion by weedy species. Several of these species, including *Vallisneria americana*, *Potamogeton nodosus* (American pondweed), and *Heteranthera dubia* (water star grass), are currently being evaluated in pond trials. The objective of these studies is to determine the relative competitive abilities of these species and of the exotic, weedy species hydrilla.

In addition, these studies will determine if an initial period of preemption increases the ability of native species to resist invasion. [*Preemption* involves an initial period of growth of the desired species in the absence of competition. This allows the desired species to get a "head start," thus preempting the resources and thereby increasing its ability to resist invasion by later arriving species.]

Native and exotic plant species (either singly or in combination) were established in containers of sediment and then grouped into populations or communities in the ponds. This research will determine the length of time required to establish native species and the effect of different periods of preemption on the subsequent ability of these native species to resist invasion by exotic species.

Two additional pond studies related to the use of competitive native plants include a long-term study of species composition in a pond planted with both native and exotic species and an evaluation of the ability of the floating-leaved species *Nelumbo lutea* (American lotus) to suppress the growth of Eurasian watermilfoil.

The large number of tanks provides adequate replication for determining the minimum concentrations of herbicides required for effective control

Investigators study ways to use selective herbicides to eliminate problem-causing exotic plant species while preserving native plants

Fish-plant interactions

Another ecologically oriented study being conducted in the LAERF ponds concerns the effects of different species and densities of submersed aquatic vegetation on the behavior and growth of juvenile largemouth bass. This study involves the use of several species of submersed aquatic plants growing in small (1-meter-diameter) pools filled with sediment and placed within large enclosures in a gravel- bottom pond. Fish communities are introduced to the enclosures, and their behavior in different types of plant cover is observed and recorded on video tape.

The current study involves the native species American pondweed and the exotic species hydrilla and Eurasian watermilfoil. The modular approach employed in this study allows the investigator to reconfigure both plant cover type and plant density relatively quickly and easily.

The information derived from this type of study will provide a better understanding of the effects of aquatic plants on fish habitat quality. Then, if compatible with aquatic plant management objectives, control operations could be designed to enhance aquatic habitat for fisheries.

Chemical Control Mesocosm System, showing water-supply pond (top), 30 tanks, and an artificial wetland (bottom)

Chemical control mesocosm system

At the LAERF, most studies of chemical control of aquatic plants are being conducted on a somewhat smaller scale, in mesocosms rather than ponds. [A *mesocosm* is a simplified, scaled-down physical model of a complex ecological system. Mesocosms are used for studying ecological processes under controlled conditions.]

One reason for this approach is the large number of replicate systems needed to determine the minimum dosages required to achieve control.

A major goal of current chemical control research is to refine the technology to achieve acceptable control by applying minimum amounts of herbicide. Once this information has been obtained through laboratory, growth chamber, and mesocosm studies, the applicability of this technology to the operational control of aquatic plant problems in large systems can be verified in ponds.

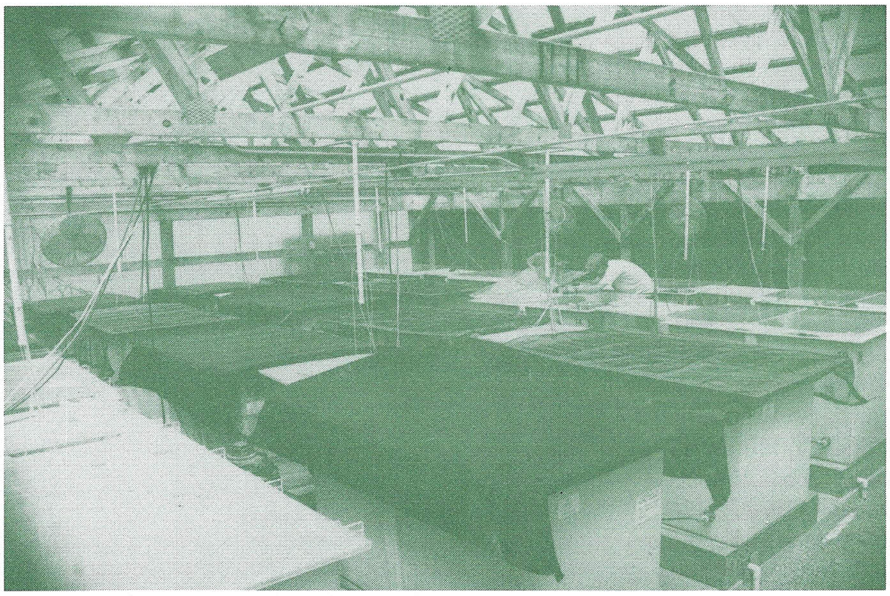
The Chemical Control Mesocosm System consists of thirty 6,000 liter-capacity fiberglass tanks (2.5 meters in diameter, 1.5 meters deep). These tanks are supplied with filtered lake water from an adjacent, lined water-supply pond. Water in the pond is alum-treated to flocculate suspended solids and precipitate dissolved phosphorus. Low-phosphorus water is necessary to prevent the excessive growth of algae, which would interfere with the conduct of the mesocosm studies.

The mesocosms are usually operated under static conditions, but water can be metered into the tanks if flow-through conditions are desired.

Submersed aquatic plants are grown in 5-liter containers of sediment that can be placed in the tanks in various configurations of species. Sediments can be chemically sterilized to prevent the growth of unwanted species of plants and animals, and amended with nutrients, if necessary, prior to mixing and placing in the containers.

Containers are usually planted and placed in an adjacent "grow-out" pond that has been prepared for producing uniform aquatic plants of the desired state of maturity for experimentation and testing in the mesocosm tanks.

Water from the Chemical Control Mesocosm System drains into two artificial wetlands. In the first wetland, waters can be held and exposed to light and oxidizing



Temperature-controlled greenhouse tanks are used for many studies of submersed aquatic plants

conditions if needed to hasten microbial and chemical breakdown of the herbicide.

In the second, larger wetland, water can be retained until no detectable herbicide remains. Indicator plants that are highly susceptible to the herbicide under study can be placed in the artificial wetlands to provide visible evidence of the effluent water's quality.

The Chemical Control Mesocosm System is being used primarily to test the effects of aquatic herbicides and plant growth regulators on target and nontarget vegetation. A current study includes experimental evaluations of innovative methods of using aquatic herbicides to achieve species-selective control.

The objective of this work is to achieve control of the target problem plant while not harming beneficial native plants. Diverse aquatic plant communities, consisting of beneficial, native species, provide water quality and aquatic habitat benefits, and may also prolong the effectiveness of aquatic plant control operations.

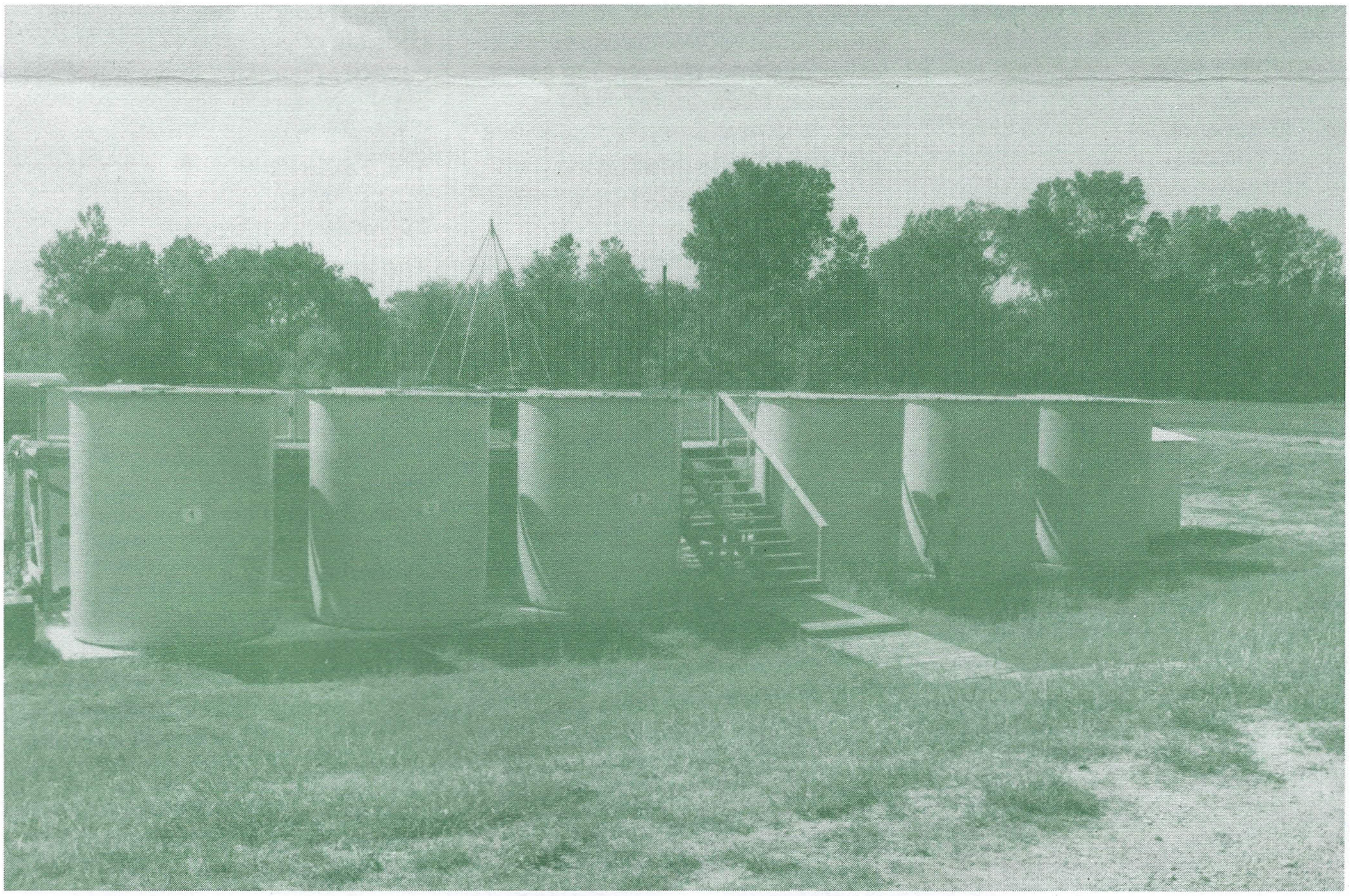
The current-generation aquatic herbicides have been developed to achieve selective control. By effectively utilizing the species-selective properties of these herbicides, managers may be able to eliminate problem species from the aquatic plant community.

The mesocosm system is also being used for evaluating the effects of plant growth regulators on target and nontarget aquatic plants. [A *plant growth regulator* is a chemical compound that either mimics or blocks the action of a natural plant hormone, thus "regulating" the growth of the plant.]

The goal of this work is to reduce the growth in height of problem species such as hydrilla and Eurasian watermilfoil. By preventing these canopy-forming species from reaching the water surface, many of the problem aspects of their growth will be eliminated while retaining the environmental benefits associated with plant cover. Reduced height growth may also enable lower growing native plants to more effectively compete with the problem species.

Temperature-controlled greenhouse tanks

The research greenhouse contains twenty 1,200 liter-capacity, temperature-controlled fiberglass tanks that can be filled with either artificial lake water or filtered pond

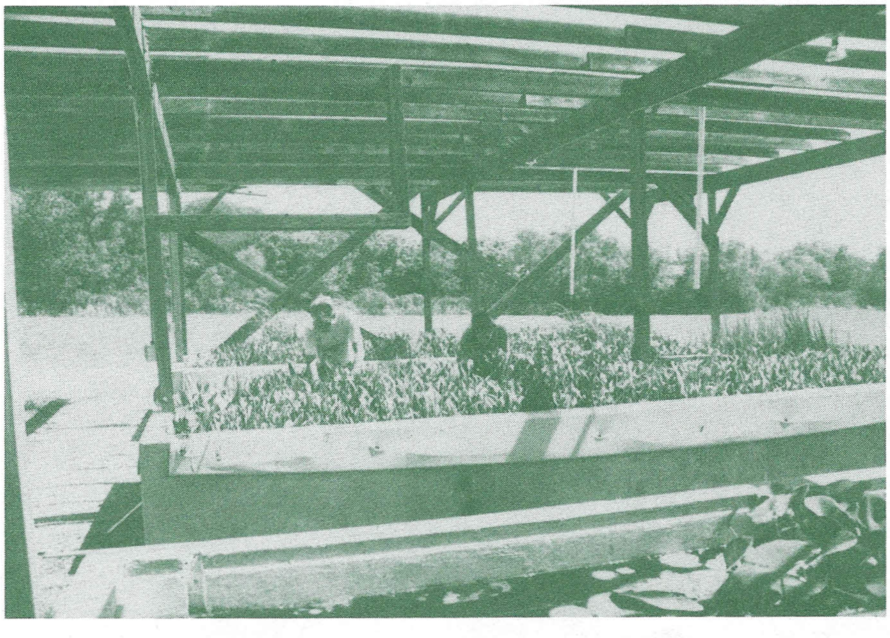


Deep tanks allow investigators to study the growth of aquatic plants under low-light conditions

Shallow-water tanks are used to study submersed aquatic and wetland plant species

water from a 20,000-liter storage tank. Studies of submersed aquatic plants can be conducted at controlled temperatures between 15 and 35 °C. These tanks can also be fitted with neutral-density shade fabric to provide 0 to 65 percent of full sunlight.

Plants are grown in individual containers of sediment, allowing sediment composition to be easily varied. A soil sterilizer is used to prepare the sediment to prevent interference from germinating seeds or spores of unwanted plant species. An aeration system provides ambient air to facilitate gas exchange and mixing. A carbon dioxide injection system can be used to augment the concentration of carbon dioxide in the airstream if needed.



Wetland mesocosms were established in flowing-water raceways to test the ability of artificial wetlands to remove nonpoint source pollutants

The greenhouse tanks are used for many types of short-term, controlled experiments to supplement longer term studies in ponds. In the few years since its development, the system has been used for studies of competition among introduced and native aquatic plants, for studies of the effects of sediment and water composition on the growth of aquatic plants, and for studies of plant growth in relation to light and temperature.

Variable depth and light tank facility

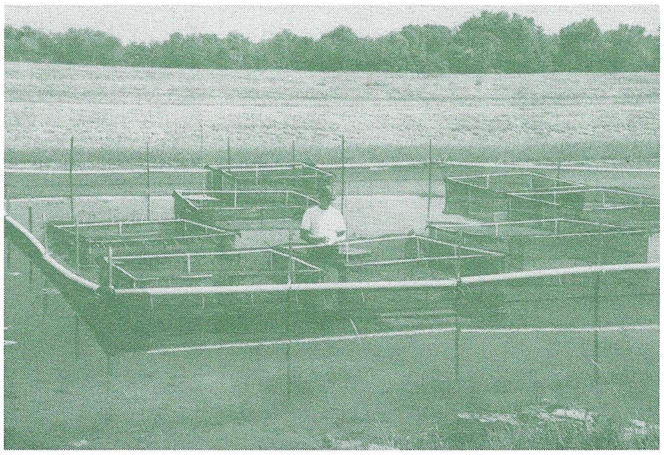
A deep-water tank system is being developed and used for studying seasonal growth and development of problem aquatic plants under low-light conditions. This system consists of eighteen 14,000 liter-capacity fiberglass tanks measuring 2.5 meters in diameter and 3 meters in depth. These tanks share both water-supply and grow-out ponds with the Chemical Control Mesocosm System.

The tanks are equipped with parabolic diffuser covers to disperse sunlight and prevent shadowing by the tank sidewalls. The interior of the tanks is finished in black to minimize reflected light. These design features were necessary to mimic open-water systems. The tanks are also equipped with small swimming pool filters to maintain desired water clarity levels.

The deep-water tank system is currently being used for studying the abilities of hydrilla and Eurasian watermilfoil to regrow from tubers, stem fragments, and root crowns under different light regimes.

Preliminary data are collected in short-term studies conducted in greenhouse tanks fitted with neutral-density shade fabric to

Alternative moist soil management strategies increase plant diversity and provide improved waterfowl habitat



Experimental plant communities that were exposed to turtle feeding are compared with those that were protected from turtles

achieve desired light levels. These preliminary data are then used to optimize the design of studies conducted in the deep-tank system. Data collected in this large-scale system are readily extrapolated to the natural environment since natural sunlight and appropriate water depths are used.

Results of these studies will increase our ability to predict regrowth rates and the spatial distribution of aquatic plants in relation to light and water depth, information that is needed for developing long-term aquatic plant management plans.

Shallow-water tank system

A shallow-water tank system is being developed and used for studies of the biology and ecology of submersed aquatic and emergent wetland plants. This system consists of twenty-four 3,000 liter-capacity fiberglass tanks measuring 2 meters in diameter and 1 meter in depth. These tanks share the same water supply as the Chemical Control Mesocosm System.

The shallow-water tank system is currently being used to conduct studies of the life cycle of submersed aquatic plants. The objective of this research is to identify periods in the life cycle when the plants are most susceptible to the application of aquatic plant controls.

The system is also being used to conduct EPA-sponsored studies of the interactive effects of adverse sediment and water composition on the establishment and growth of aquatic and wetland plants.

Flowing-water raceways

The 18 flowing-water raceways are supplied with water from the same Lake Lewisville source that feeds the ponds. These raceways are 0.9 meter wide, 0.6 to 0.75 meter deep, and 6 meters long. They are used for culturing or holding aquatic plants or animals and for conducting small-scale studies of the effects of flow or constituent loading on aquatic plants.

Local reservoirs

In addition to the ponds, Lewisville Lake, located immediately adjacent to the LAERF, and Lake Ray Roberts, a new Corps reservoir located 5 river miles upstream from Lewisville Lake, provide additional opportunities for large-scale research.

Because of its past history of operation, including a recent 2-meter increase in conservation pool, Lake Lewisville currently has very little aquatic vegetation. This relative lack of vegetation presents certain unique aquatic plant research opportunities.

Preparations are being made to establish experimental plantings of beneficial native species in this reservoir. Since the lake currently lacks submersed aquatic plants, fish populations are expected to benefit from the additional cover that plantings of selected native species will provide. This research will be a collaborative effort between LAERF and TPWD regional personnel.

Lake Ray Roberts has recently become infested with hydrilla. The infestation is in the early stages, and with the timely application of appropriate control technology, it may be possible to eradicate the hydrilla. The closeness of this lake to the LAERF and the early detection of the hydrilla infestation represent an excellent opportunity to closely document both the spread of a problem species and the results of various control technologies.

Support for other Corps programs

Although research conducted at the LAERF to date has focused primarily on aquatic plants and their control, the ponds and mesocosms are also suitable for conducting research under other Corps research programs such as the Water Quality Research Program and the Wetlands Research Program (WRP). The ability to control and monitor water levels, inputs, and outputs makes the ponds ideally suited for conducting process-oriented aquatic ecosystem and wetland studies.

Several WRP projects have been initiated at the LAERF. One project is a four-pond evaluation of moist soil management strategies for waterfowl habitat enhancement. In this study, an alternative water-level management plan is being compared to traditional moist soil management practices. Preliminary results indicate that the alternative plan increased plant diversity and provided a more favorable waterfowl habitat.

Another WRP project involved a study of nonpoint source pollutant processing in artificial wetlands. This study measured the ability of artificial wetland mesocosms to process the pre-emergent herbicide, atrazine, in simulated agricultural runoff. Because of its widespread use and its environmental mobility, atrazine is a frequent contaminant of surface waters. The study demonstrated that artificial wetlands could potentially protect receiving waters from atrazine contamination. The half-life of atrazine in the artificial wetlands averaged 8 to 9 days compared to 40 to 60 days in non-wetland control tanks. Atrazine samples from this project and several WRP field studies were processed and analyzed in the LAERF analytical lab using a newly developed immunoassay procedure.

A third WRP project involved determination of the effects of wetland vegetation on water flow and sedimentation. The study utilized a section of the concrete-lined pond drainage system as a flume, employing an upstream pond as a water source. The flume had earlier been planted with aquatic and wetland plants by LAERF personnel. The study inexpensively demonstrated the important effects of wetland vegetation in attenuating high-water flows.

Support to other agencies

The LAERF is also available to support research for other agencies when this work is compatible and complementary to the ongoing APCRP research. Reimbursable research has included several recent and ongoing studies for the Environmental Protection Agency (EPA) and a continuing study for the Tennessee Valley Authority (TVA).

Environmental Protection Agency

The restoration and subsequent use of aquatic and wetland plant communities as part of a remediation plan for chronically polluted Onondaga Lake was evaluated under an EPA Clean Lakes Program Demonstration Project. The LAERF portion of the project evaluated the influence of different Onondaga Lake sediments on plant establishment and growth. Subsequent investigations considered the influence of historical, current, and predicted future water chemical compositions on establishment and growth of aquatic plants. Additional studies identified submersed aquatic and emergent wetland plant species that tolerated the adverse sediment and water chemical composition and thus might be useful in the remediation project.

The information obtained in these studies was incorporated into an in-lake, multiagency demonstration project. In collaboration with researchers from the New York Department of Environmental Conservation and Rensselaer Polytechnic Institute, LAERF personnel successfully restored aquatic plant communities in a demonstration project and confirmed the beneficial effects of these restored aquatic plant communities to improve aquatic habitat quality in this severely degraded lake. In addition to directly benefitting the EPA and the Onondaga Lake Management Conference, the results of this research will also benefit the Corps and other agencies concerned with the aquatic environment.

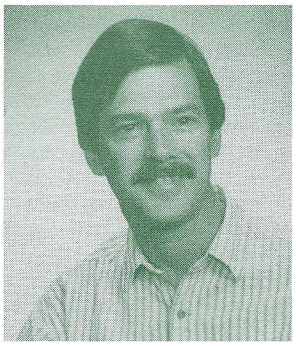
In another EPA-funded project, LAERF researchers successfully completed an experimental planting of desirable aquatic and wetland plants at an artificial wetland site adjacent to Lake Ray Roberts. The study documented several important factors critical to the successful creation of an artificial wetland within this geographical region and appropriate to efforts in other regions of the country.

Tennessee Valley Authority

A TVA-funded effort is concerned with the potential effects of herbivorous turtles on the species composition of submersed aquatic plant communities. Recent dramatic decreases in submersed aquatic plant populations in Guntersville Reservoir may have left populations of turtles that are too large to be supported by current quantities of vegetation. TVA is concerned with the impacts of these turtles on recovering plant populations and also their potential impacts on fish and invertebrate populations if the lack of plants causes a switch in their diet. The study involves a collaborative field effort with the University of Mississippi, feeding studies conducted in tanks at the LAERF, and a pond study comparing biomass and species composition of submersed aquatic plant communities as affected by the presence or absence of turtles.

Future activities

With the recent expansion of research capabilities described in this bulletin, the LAERF is expected to play an increasing role in the research and development of aquatic plant control technology. These capabilities can also contribute to an increase in the Corps' ability to wisely manage its freshwater wetlands, reservoirs, and waterways.



Dr. R. Michael Smart *is an ecologist in the Environmental Laboratory, U.S. Army Engineer Waterways Experiment Station (WES). He is stationed at the Lewisville Aquatic Ecosystem Research Facility in Lewisville, Texas, and has been instrumental in its development and operation. His research is concerned with the biology, ecology, and management of aquatic plants. Michael has a Bachelor of Science degree in Biology from the University of Southern Mississippi and a Ph.D. in Marine Biology from the University of Delaware.*

Lewis Decell *is Manager, Environmental Resources Research and Assistance Programs, in the Environmental Laboratory, WES. His responsibilities include management of the Corps' Aquatic Plant Control, Water Quality, and Natural Resources Research Programs and the Water Operations and Natural Resources Technical Support Programs. Lewis holds a Bachelor of Science degree in Civil Engineering from Mississippi State University and a Master of Science degree in Environmental Engineering Sciences from the University of Florida.*

Center for Aquatic Plant Research and Technology

In the near future, the Corps of Engineers' Center for Aquatic Plant Research and Technology (CAPRT), recently established at the Waterways Experiment Station (WES), will invite other Federal agencies to hold membership in the CAPRT and to collectively serve as a guidance committee that will set the future directions for the Center.

According to Lewis Decell, Director of the CAPRT, the Center will provide a single element for coordination and facilitation at WES for all aquatic plant research and technology transfer to

- Congressmen and their staffs.
- Army staff.
- Corps Headquarters, divisions, districts, and field operating elements.
- Installation Commanders and other Department of Defense users.
- Other Federal agencies.
- State agencies, academia, and private industry.

The CAPRT will address Federal-wide aquatic plant research and technology cordination needs for both civil and military programs. It is also intended that the CAPRT will provide clearinghouse services to the overall science of aquatic plant management, for those services that are not or cannot be facilitated by current Federal programs because of mission objectives.

A more detailed Information Bulletin will be published after the guidance committee has been formed and initiates the task of identifying functional activities.

PRINTED ON RECYCLED PAPER

This issue reports on the facilities and capabilities of the Lewisville Aquatic Ecosystem Research Facility in Lewisville, Texas. Research conducted at this experimental pond facility supports studies of the biology, ecology, and management of aquatic plants.

AQUATIC PLANT CONTROL RESEARCH PROGRAM

This bulletin is published in accordance with AR 25-30 as one of the information dissemination functions of the Environmental Laboratory of the Waterways Experiment Station. It is principally intended to be a forum whereby information pertaining to and resulting from the Corps of Engineers' nationwide Aquatic Plant Control Research Program (APCRP) can be rapidly and widely disseminated to Corps District and Division offices and other Federal and State agencies, universities, research institutes, corporations, and individuals. Contributions are solicited, but should be relevant to the management of aquatic plants, providing tools and techniques for the control of problem aquatic plant infestations in the Nation's waterways. These management methods must be effective, economical, and environmentally compatible. The contents of this bulletin are not to be used for advertising, publication, or promotional purposes. Citation of trade names does not constitute an official endorsement or approval of the use of such products. This bulletin will be issued on an irregular basis as dictated by the quantity and importance of information to be disseminated. Communications are welcomed and should be addressed to the Environmental Laboratory, ATTN: J.L. Decell, US Army Engineer Waterways Experiment Station, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199, or call AC 601/634-3494.

ROBERT W. WHALIN, PhD, PE
Director

DEPARTMENT OF THE ARMY
WATERWAYS EXPERIMENT STATION, CORPS OF ENGINEERS
3909 HALLS FERRY ROAD
VICKSBURG, MISSISSIPPI 39180-6199

OFFICIAL BUSINESS
CEWES-EP-L

BULK RATE
U.S. POSTAGE PAID
Vicksburg, MS
Permit No. 85