ABSTRACTS

FORTY-FIRST ANNUAL MEETING

"SPREADING THE KNOWLEDGE THROUGH SCIENCE EDUCATION"

THE AQUATIC PLANT MANAGEMENT SOCIETY, INC.

MARRIOTT CITY CENTER
MINNEAPOLIS, MINNESOTA U.S.A.
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The Abstracts were compiled from the best information available at the time of printing. Please bring any omissions or errors to the attention of David Tarver, Program Chair. Thank you for your understanding.

Session I: Plenary

The "Business" of Aquatic Plant Management – Why Do We Do What We Do?

Jim Schmidt
President, The Aquatic Plant Management Society, Inc., Applied Biochemists, Germantown, WI

A simple definition of a business is an organization that supplies goods and/or services to meet customer demands with the purpose of deriving a profit from this exchange. We each need to ask the question, how does what we do as a professional organization, as an industry, and as individuals contribute to the "business" of aquatic plant management? What value do we have to offer? Who are our "customers"? What are our customers' "demands" or objectives? How do we meet them? Who is our competition? How and where can we profit? A narrow view is simply one of economics. However, a broader vision encompasses more than simply dollars and cents. Many of us in this industry are here because we sought the challenges of managing the aquatic environment. We were unaware of the required prerequisite for public education, explaining why we do what we do. This is not only a responsibility, but it is an opportunity for each of us to sell the public on the benefits of aquatic plant management. Benefits not only for human water users, but benefits for the health of the aquatic environment. Profits from aquatic plant management are measured as a ratio of the benefits gained vs. the costs of efforts expended to achieve them. Are we producing a profit to support and expand the "business" of aquatic plant management?

National Invasive Species Management Plan - Roadmap to the Future?

Randall K. Stocker
UF/IFAS Center for Aquatic and Invasive Plants, Gainesville, FL

In 1999, President Clinton issued Executive Order 13112 establishing the National Invasive Species Council, co-chaired by the Secretaries of the Departments of Interior, Agriculture, and Commerce. That Order also established the Invasive Species Advisory Committee, which includes representation of the Aquatic Plant Management Society and many other nonFederal practitioners and stakeholders, providing advice and input to the Council on January 18, 2001, the Council approved the first edition of the National Invasive Species Management Plan, after extensive consultation with many organizations and individuals, input from the Advisory Committee, five public listening sessions, and a 60-day public comment period.

The Management Plan focuses on several urgent priority areas:

- coordination among federal agencies, and international cooperation
- prevention (assessing and better controlling pathways of introduction)
- development and use of risk assessment protocols
- early detection and rapid response to newly-discovered invasive species
- control and management of invasive species
- restoration of natural areas degraded by invasive species
- research and monitoring
- information sharing, education and public awareness
- increased resources and funding

The complete plan is available online at www.invasivespecies.gov

This is our first look at an evolving national-level process to address the numerous invasive pest issues facing our country. It strongly emphasizes the importance of international coordination and cooperation, and at the same time stresses the importance of grass-roots (literally, in some cases...) management and monitoring programs, especially for invasive plants.

The Aquatic Ecosystem Restoration Foundation - Five Years of Progress

Michael D. Moore
Executive Director, Aquatic Ecosystem Restoration Foundation, Lansing MI

From it beginning in 1996 the Aquatic Ecosystem Restoration Foundation has fulfilled its mission as a nonprofit organization dedicated to the environmentally-sound restoration and management of aquatic and wetland systems via research and development, public education, regulatory interactions and public/private/academic partnerships.

Virtually every aspect of human activity relies on adequate and high-quality water resources, and every day increased pressure is being placed on these unique and life-sustaining ecosystems. Unfortunately, invasive vegetation is causing significant ecological and economic impacts on critical aquatic, wetland, and riparian systems in the United States. These plant species degrade and/or diminish water quality, human health, fisheries, water-bird habitat, recreation, aesthetics, and property values. Although traditional plant management techniques and tools are available, there is pressing need to develop new strategies and refine existing ones that can selectively control these aggressive weeds in an environmentally compatible fashion.

The Aquatic Ecosystem Restoration Foundation (AERF) has sponsored numerous activities over its five years. A review of the successes of the organization in the areas of research, development, education and partnerships will be presented. In addition, a discussion of newly planned research and educational projects will be presented including an in-depth discussion of a proposed Best Management Practices manual on aquatic plant management with an emphasis on fish and wildlife habitat.

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Session II: More Regulations On The Way?

California's Waterhyacinth and *Egeria densa* Control Programs: Compliance with the National Pollution Discharge Elimination System (NPDES) Permit Requirements and U.S. Fish &Wildlife "Section Seven"

Lars W. J. Anderson[1] and Patrick Thalkan[2]
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Recent Federal court actions have necessitated the issuance of NPDES permits for applications of aquatic herbicides used in both the waterhyacinth control and Egeria control programs in California. Permits were issued in March and April 2001 for these management programs, and require extensive environmental monitoring and toxicity testing as well as compliance with conditions imposed by the Endangered Species Act. The process required by these new regulatory constraints and well, as their fiscal impacts are significant changes in typical aquatic pest-management procedures. The compliance steps taken in California may provide a model for responding to similar changes in other states. We will discuss the background and development of both invasive species management programs in light of NPDES issues. (Since the regulatory climate is changing very rapidly, the most recent approaches to compliance, including "General NPDES" permits may be in effect by July, 2001.)

State and Federal Pesticide Regulatory Agencies-Their Roles and The Need for Communication

Paul Liemandt
Environmental Response and Enforcement Section, Agronomy and Plant Protection Division, MN Dept. of Agriculture, St. Paul, MN

My comments and panel participation are intended to offer a perspective on aquatic pesticide issues from a manager of enforcement programs for a state pesticide regulatory agency. State pesticide regulatory agencies and USEPA have a long standing relationship in regard to the cooperative administration and enforcement of federal ("FIFRA") and state pesticide laws. Pesticide product registration, distribution, use, storage and disposal are strictly controlled. Most enforcement activities for pesticide misuse are brought at the state level of government, either by imposition of state pesticide law, or alternatively, state fish & wildlife law. State agencies having authority to permit or otherwise regulate the use of aquatic site pesticides have traditionally communicated closely with their state pesticide-regulating agency; this is not always true in regard to contacts and understandings with agency(s) responsible for implementing safe or clean water regulations. Recent federal litigation has highlighted apparent conflict between federal pesticide and water protection law, and by implication some existing but less than properly functioning agency relationships. Identified stakeholders, particularly private property owners, farmers, and water management interests need to engage in immediate and constructive dialogue in order to protect water and other natural resources, the publics health, and the ability to (continue to) efficaciously manage nuisance aquatic plants. Understanding the past and current role of state lead pesticide regulatory agencies is essential to a successful dialogue and resolution of current issues.

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Session III: Education And Outreach – Aquatic Plant Management Endeavors

APMS Cooperative Elementary Education Project

Jeffrey D. Schardt
Florida Department of Environmental Protection, Tallahassee, FL

The Aquatic Plant Management Society and its regional chapters have been effective in conducting research and transferring technology to managers, but relatively little has been done to inform the public on the need and options for invasive plant control. Until invasive plant management becomes part of the nation's culture, managers should expect little understanding and therefore little support of this complex program. Educators at all grade levels want new materials to incorporate into their science curricula, especially information that includes higher priority subjects like math and language arts. The APMS Education and Outreach Committee has developed such a packet designed for one week classroom and homework activities to expose 3rd and 4th grade children and their parents to invasive aquatic plants. Five plants that cause national or regional concern are included in the packet: hydrilla, water hyacinth, purple loosestrife, Eurasian watermilfoil, and giant salvinia. Presentation format, and activities will be discussed along with sponsorship and distribution of the packets. A brief overview of other projects at the middle and high school levels also will be presented.

Our Plants, Their Plants, These Plants, Those Plants

Vic Ramey
Center for Aquatic and Invasive Plants, Gainesville, FL

Despite concern and efforts so far, America's lakes, rivers, marshes and swamps are under attack now more than ever. At least 60 non-native aquatic plants are currently recorded in the natural areas of the U.S. However, wetland degradation by invading plants is a global problem: plants from over there somehow make it here; plants from here somehow make it over there. We curse their plants; they curse our plants.

This presentation will review infestations in the rest of the world by plants native in the U.S. Would you believe that coontail (*Ceratophyllum demersum*) isn't welcome in New Zealand!

MN DNR Aquatic Plants Education and Outreach

Michelle Bratager
MN DNR Ecological Services, Ecosystem Education Program, St. Paul MN

The MN Dept of Natural Resources has emphasized aquatic plant education as a component of several programs; Exotic Species Program (watercraft inspections), Ecosystem Education, Aquatic Plant Management Program (APM) and Aquatic Plant Restoration Program (APR). An overview of activities and products for each of the above programs as they relate to aquatic plant education and outreach will be provided.

Exotic Species Program (watercraft inspections): The goals of this program are to increase awareness of exotics and problems caused b y exotic invasions, and to teach boaters how to inspect and clean their own watercraft and trailers. Young adults are hired through Minnesota Conservation Corps to provide information and education to boaters at public access sites throughout Minnesota. Over 40, 000 boaters are contacted annually.
Ecosystem Education program: is currently coordinating the production of an interactive CD "Restore Your Shore" which will focus on shoreline restoration projects for shoreland property owners. The CD will include a native plant guide, a set of demonstration site sand a how-to quide. Other related projects include the popular book "Lakescaping for Wildlife and Water Ouality" (DNR Non-Game Wildlife), 14 statewide workshops on Shoreland Management and Restoration conducted in 2000, and 14 lakescaping demonstration projects 2000-2001 (DNR Fisheries).

Aquatic Plant Management Program (APM): in addition to brochures, newsletter articles, and presentations, this program has launched a media campaign to include billboard, radio, and newsprint for this spring and summer 2001. The message; before you clear all that vegetation. ...call the DNR. You can still enjoy your shoreline and provide habitat needed for the other lakeshore residents.

Aquatic Plant Restoration Program (APR): will be offering park maintenance workshops to provide training to parks workers on shoreline maintenance: identifying the undesirable plants, prescribed burns, and in general, alternatives to

mowing. A park specific maintenance manual will be provided for parks participating as demonstration sites. A general park maintenance manual will also be developed. This is a two-year project to be completed by 2002.

Invasive Aquatic and Wetland Weeds: The Educational Role of North Carolina Sea Grant

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The popularity of water gardens in the United States has increased exponentially over the past ten years. This has led to the establishment of countless aquatic and wetland plant nurseries to provide the variety of attractive plants demanded by the public, and most of the plants that are cultivated are species which have been introduced from other parts of the world. These plants are selected for their beauty, hardiness, and ease of cultivation. Every spring articles about "water features" appear in gardening magazines and newspaper supplements, and plants for these are available at local garden centers and nationwide chains. Many of these plants are marketed (both unintentionally and intentionally) under erroneous scientific and common names. They also are being promoted widely by many new business establishments which formerly had no experience with this type of vegetation. Mail order and internet advertising of aquatic and wetland plants also has increased dramatically in the last decade. The result of all of these activities has been the inadvertent introduction of highly invasive pest plants (including many Federal Noxious Weeds) into our waters. The nursery industry, the general public, and many resource agencies, however, have no idea that many of the plants promoted for use in aquaria, water gardens, and ornamental pools are causing or have the potential to cause serious environmental problems. A major educational effort is needed at all levels to combat this trend. In 1999, a nationwide educational program was initiated by the Sea Grant program to combat the increasing problems associated with the proliferation of water gardening. As a part of this initiative, North Carolina Sea Grant and the North Carolina Cooperative Extension Service have produced a guide to the identification of a select group of the most invasive and environmentally destructive aquatic and wetland plants that are of concern in the United States. The twenty-two plants included in the manual were selected by a national steering committee of resource managers, aquatic weed scientists, and others having concern about the impacts of invasive aquatic and wetland vegetation. The manual is semi-technical in nature and is directed primarily toward resource agency personnel who have little or no knowledge and experience with aquatic or wetland plants. It contains color photographs, occasional line drawings, and an accompanying text written without botanical jargon that points out key identifying characteristics and provides brief information on the problems caused by the plants and related environmental information. The manual will be available from North Carolina Sea Grant and cooperating Sea Grant offices.

AQUAPLANT: A Web-Based Outreach Program for Management of Aquatic Vegetation

Michael P. Masser
Department of Wildlife and Fisheries Sciences, TAMUS, College Station, TX

Most private impoundments have multiple-uses for either livestock watering, irrigation, aquaculture, and/or recreation. Infestations of aquatic vegetation can have negative impacts on these multiple-uses by: 1) hindering feeding and harvesting operations, 2) reducing recreational access, 3) clogging irrigation systems, 4) increasing evaporation rates by as which as 30%, 5) increasing eutrophication rates by 2- to 3-fold, 6) negatively impacting water quality for fish and wildlife species, 7) shifting the balance of the fish population (e.g. stunting), and 8) increasing breeding areas for mosquitoes and other insect pests.

Aquatic vegetation identification and management in private waters, including aquaculture, is a perplexing challenge for landowners, Extension personnel, and others attempting to assist them. Many species of native and non-indigenous aquatic plants invade and establish nuisance communities in private impoundments. Fisheries biologists, Extension personnel, and purveyors of aquatic herbicides in general have limited backgrounds in aquatic vegetation identification and control options. Yet with several million private impoundments in U.S. this is a common Extension clientele demand. County Extension personnel, landowners, and the public need expert assistance with aquatic vegetation management. Extension specialists with the Department of Wildlife and Fisheries Sciences developed a deck of aquatic plant identification cards, posters, and a web-based knowledge base (AQUAPLANT) to help identify and manage (e.g., control) aquatic vegetation problems. The three deliverables developed by the project will be demonstrated.

Great Lakes Region's Information / Education Strategy for Nonindigenous Aquatic Nuisance Species
William (Jay) Rendall
Minnesota Department of Natural Resources, St. Paul, MN

An array of federal, state, and provincial agencies, under the auspices of the Great Lakes Panel on Aquatic Nuisance Species (ANS), have jointly produced the Information/Education Strategy to help prevent the spread of aquatic nuisance species. The information/education strategy was recently revised and targets Great Lakes region user groups, resource managers, researchers, and policy makers. The purpose of the strategy is to facilitate regional coordination and build partnerships that will strengthen the effectiveness of ANS information/education activities in the Great Lakes region. Key parts of the regional education strategy and examples of education efforts (such as identification cards, radio spots, signs, and videos) used in Minnesota and other states will be presented.

No One Way: Reaching Diffuse Target Audiences to Reduce the Spread of Invasive Aquatic Plants
Heather M. Crawford
Connecticut Sea Grant Extension Program, New Haven, CT

In spite of their ability to drastically impact recreation, transportation, water supply infrastructure, and natural ecosystems, in terms of public awareness and outreach efforts, invasive aquatic plants are often the afterthought or secondary issue in campaigns targeting terrestrial weed plants or invasive aquatic animals. The most important target audiences to be reached in order to reduce the introduction and spread of invasive plants, such as boaters, aquarium hobbyists, water gardeners, waterfront property associations, landscape architects and other commercial property managers, tend to be diffuse and difficult to reach by traditional education methods. Poor communication between organizations interested in ecosystem preservation or environmental regulation within the same state or region may lead to contradictory information reaching the public or duplication of efforts may waste scarce outreach resources. Engaging interested individuals in monitoring and control efforts for invasive aquatic plants requires significant, long-term commitments in planning, training, equipment, and financial and technical support by both the individuals and the coordinating organization.

In spite of the difficulties, there are many successful invasive aquatic plant outreach efforts around the country. Examples of projects utilizing volunteers to identify and control invasive plant populations, sharing resources within a region and using the Internet as a communication tool will be discussed along with an update on the current Aquatic Nuisance Species Research and Outreach proposal cycle within the NOAA National Sea Grant Office.

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Session IV: Aquatic Ecological Studies

Does Fish Predation Limit Milfoil Weevil Populations?

Darren M. Ward and Raymond M. Newman
University of Minnesota, Fisheries and Wildlife Department, St. Paul, MN

The native aquatic weevil *Euhrychiopsis lecontei* is a potential biological control agent of the exotic macrophyte Eurasian watermilfoil (*Myriophyllum spicatum*). In some lakes *E. lecontei* has successfully suppressed *M. spicatum*; however, in other lakes *E. lecontei* populations have failed to reach sufficient density to suppress Eurasian watermilfoil. It is not known what limits *E. lecontei* populations in lakes where they fail to control Eurasian watermilfoil, butsome evidence suggests that sunfish predation may be important in limiting weevil populations. We conducted field experiments using cages to manipulate fish density in Cedar Lake, Minneapolis, Minnesota to assess fish effects on weevil populations and weevil stocking success. Two treatment factors, cage type (fish exclosures-open cages) and weevil stocking (stocked-not stocked), were randomly assigned to twenty cages in the littoral zone (n=5). Adult and larval weevil density was marginally higher in fish exclosures than open cages through the 2000 experiment (Repeated Measures ANOVA p=0.1); adult and larval weevil densities were significantly higher in exclosure cages at the end of the experiment (ANOVA p=0.05). There were no significant treatment effects on watermilfoil growth in cages, but larval density was negatively related to milfoil growth (p=0.1). A weevil population model shows that weevil populations are sensitive to adult survival; adults are the life stage most vulnerable to fish predation. Projected weevil populations increase dramatically with longer adult life spans. Our research suggests that fish predation may prevent *E. lecontei* populations from reaching sufficient density to suppress Eurasian watermilfoil.

Distribution of Cape Ivy, a South African Vine Threatening Riparian Zones of Coastal California

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[4] *Plant Protection Research Institute, Biosystematics Division, South Africa*

Cape ivy *(Delairea odorata* Lem.) is an asteraceous twining perennial, native to southern Africa. Widely used as an ornamental vine, Cape ivy has become invasive in at least three United States. In California and Oregon, it has, thus far, only become naturalized in coastal regions, and is an especially aggressive invader of riparian corridors and coastal scrub communities. However, in Hawaii, it primarily invades upland native forests above an altitude of 500 meters. In preparation to launching surveys in Africa to locate potential biological control agents, we needed to determine the precise areas and habitats in which this vine occurs there. After examining all the specimens of Cape ivy at six of the largest herbaria in South Africa, it was clear that this plant was uncommon, poorly known even by botanists familiar with the group, and that the sites at which it had been collected were restricted and widely scattered. Our surveys of Cape ivy in South Africa and in the USA have greatly increased the known distribution and provided insights into the diverse habitats in which this vine can thrive.

Euhrychiopsis lecontei Attraction to Watermilfoil Exudates

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[3] *Fisheries, Wildlife & Conservation Biology, University of Minnesota, St. Paul, MN*

The native weevil *Euhrychiopsis lecontei* is a specialist herbivore on watermilfoils that has recently undergone a host range expansion from its native host northern watermilfoil, *Myriophyllum sibiricum*, to the exotic host Eurasian watermilfoil, *Myriophyllum spicatum*. Through a series of two-way choice tests, we have found that the weevil prefers Eurasian watermilfoil to northern watermilfoil and that the attraction is chemically mediated. Weevils choose and are located more often on Eurasian watermilfoil and its isolated exudate components than on northern watermilfoil or its exudates. Bioassay-driven fractionation of watermilfoil exudates were used to identify specific chemicals that attract the milfoil weevil. A combination of anion exchange, sizing, and reverse-phase high performance liquid chromatography were used to isolate one component of the exudates that attracts the weevil. Chemical ionization-mass spectroscopy and ^{1}H and ^{13}C nuclear magnetic resonance were used to identify that component, which is water soluble with a molecular weight of 112. Through continued research we will determine whether additional compounds are involved in weevil attraction or act synergistically with the

isolated compound. Further study on the seasonal production of attractive components found in milfoil exudates and the presence of attractants in other milfoils will help determine whether the isolated attractant can be used to facilitate Eurasian watermilfoil biocontrol.

Restoration of Native Vegetation in Lake Bellwood, Texas (WU 33084)

Gary O. Dick[1], R. Michael Smart[2], and Richard Ott[3]
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[2] *U.S. Army Engineer Research and Development Center, Environmental Laboratory, Lewisville Aquatic Ecosystem Research Facility, Lewisville, TX*
[3] *Texas Parks and Wildlife Department, Tyler, TX*

Selective chemical control of exotic plants and introduction of native plants were combined to demonstrate integrated pest management in a 170-acre lake located in Tyler, Texas during 1998-2001. Hydrilla (*Hydrilla verticillata*) was first reported from Lake Bellwood in the early 1990's, and by late summer, 1997 covered an estimated 80% of the surface area, crowding out native species previously found in the lake. Endothall was used in an attempt to selectively reduce the hydrilla colony while incurring minimal damage to existing and establishing native plants. At low rates, endothall has been shown to control hydrilla without adversely affecting several native plant species.

Native aquatic plants present before herbicide application included American lotus (*Nelumbo lutea*), spatterdock (*Nuphar luteum*), white water lily (*Nymphaea odorata*), coontail (*Ceratophyllum demersum*), and watershield (*Brasenia schreberi*). Following initial treatment, additional native species were introduced, including eelgrass (*Vallisneria americana*), American pondweed (*Potamogeton nodosus*), Illinois pondweed (*P. illinoensis*), water stargrass (*Heteranthera dubia*), and common elodea (*Elodea canadensis*). These were protected from grazing (common carp, semi-aquatic turtles) with cages of various types over the course of the project.

Existing native colonies increased in size following initial herbicide applications, although some species may have declined. Introduced plant species became well established within cages and in many cases spread from protected areas. Periodic recovery of hydrilla led project managers to use higher than selective rates of endothall during the first two years, and most native vegetation was adversely impacted. Spatterdock, eelgrass, and water stargrass appeared to be the most resistant species. Lower rates are currently being used to assess continued management of hydrilla without unduly affecting simultaneous restoration of native plants.

Fish Population Recovery Following a Hydrilla Management Strategy in Lake Bellwood, Texas (WU 33186)

Richard Ott
Texas Parks and Wildlife Department, Tyler, TX

Prior to establishment of hydrilla at Lake Bellwood, Texas, in the mid 1990's, the largemouth bass (*Micropterus salmoides*) population was characterized as a high quality fishery, with a proportional stock density (PSD) in the 40-60% range. By 1998, when hydrilla covered over 80% of the lake area, largemouth bass PSD had fallen to 28% in the spring and 16% by the fall. Both of these values are below the recommended range and are indicative of a population dominated by small fish (recruits less than 12 inches long). Average growth rates (both as back-calculated length and length at age of capture) were below the average for the Pineywoods ecological area.

Following herbicide treatment of hydrilla in summer 1998, the structure of the largemouth bass population changed significantly by spring 1999. Where the largemouth bass population was dominated by small fish in spring1998, by spring 1999, the density of small fish had decreased (presumably a result of increased predation by large fish) and the size distribution of large fish had improved greatly. PSD of largemouth bass in spring 1999 was back into the 40-60% range. This improved size distribution carried over to fall of 1999 and was still present in spring and fall 2000. Growth rates in fall 1999 and 2000 showed improvement over 1998 with young fish approaching the ecological region average and large fish exceeding the average.

Shoreline Restoration in Minnesota - Advances and Challenges

Jennifer S. Winkelman and Michael G. Halverson
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The intensity and style of development along Minnesota's lakes and rivers contributes to the degradation of plant communities that create shoreline habitat. The physical structure of shorelines is dramatically changed when vegetation and ice ridges are removed and replaced with sand beaches, rock or mowed lawn to the water's edge. Chemical and other physical methods are frequently used to remove riparian and aquatic plants. The loss of shoreline habitat affects fish and wildlife habitat, erosion, water quality, aesthetics and other lake-related values.

Often the removal of shoreline vegetation is optional, reflecting a lack of information and based on a set of expectations not compatible with good stewardship. Alternatives exist that promote shoreline ecology as well as aesthetic and recreational enjoyment of the lakeshore.

The Minnesota Department of Natural Resources' Aquatic Plant Restoration (APR) Program was created in 1998 to protect and restore riparian and littoral habitat. Through a multi-pronged effort of habitat projects, education, coordination and research, APR implements new techniques and promotes ecological standards for shoreline projects. To date, APR has been involved with more than 75 habitat projects, hundreds of volunteers, numerous education and outreach efforts and research that is advancing restoration knowledge.

APR's encompassing vision and partnerships combined with the DNR's legal jurisdiction in public waters have facilitated the development of consistent messages and ecological standards for shoreline projects. The APR program, specific approaches to shoreline restoration, and ongoing and future challenges will be discussed.

Allelopathic Studies Between the Red Tide Organism *Gymnodinium breve* and the Wild Green Alga *Nannochloris spp.*

Melissa L. Derby, Michael Galliano, Dean F. Martin, and Joseph J. Krzanowski
University of South Florida, Tampa, FL

Since the 1970s, the number of harmful algal blooms that occur in the United States has increased. The harmful algal bloom in Florida, known as *Gymnodinium breve*, occurs every 3-5 years unless conditions for an outbreak arise. The concept of allelopathy has been looked at as a means to mitigate these blooms. Here we use the wild algal strain *Nannochloris spp.* and its allelopathic chemicals, known as pseudo-aponin and aponin, to bring the *Gymnodinium breve* to a resting state and control the release of the harmful toxins produced. Other allelopathic agents and their aponins are also being explored. The study involved looking at the conditions in which the toxins, known as brevetoxins, are released from *Gymnodinium breve*, the toxicity of the allelopathic agent, *Nannochloris spp.*, and the toxicity that occurs when the allelopathic interaction takes place. The studies were done in an agitated and unagitated state and at 24,48, and 72 hours. Preliminary results show that the *Gymnodinium breve* must be stressed to allow toxin release and that the allelopathic interaction had caused no toxin release.

Between a Dark and a Dry Place: Establishing Native Aquatic Plants in Turbid Reservoirs with Fluctuating Water Levels (WU 33084)

R. Michael Smart[1], Gary O. Dick[2], Mark Webb[3], and Richard Ott[3]
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[3] *Texas Parks and Wildlife Department, Tyler, TX*

The objective of this Aquatic Plant Control Research Program work unit is to develop guidance that will enable resource managers to successfully restore diverse communities of native aquatic plants in aquatic ecosystems that have been degraded by long-term infestations of exotic species, or to establish desirable native plants as a deterrent to weed invasion in unvegetated systems. The obstacles to natural establishment that must be overcome include a lack of propagules, adverse environmental conditions, and excessive grazing and disturbance by herbivores and omnivores.

In a cooperative effort, we have been attempting to demonstrate and refine techniques for establishing native aquatic plants in seven reservoirs representing diverse environmental conditions. Over twenty species were planted, with and without herbivore exclosures, during each of the past three years. Plant survival was affected by water level fluctuations and by herbivory. Water levels in all of the lakes dropped soon after planting, exposing virtually all of the plantings. The effects of

these low water events depended on their timing and duration and on the species of plant. Given adequate time for establishment prior to exposure, many species proved able to withstand even prolonged exposure. Because water level fluctuations proved to be so important during the first year, multiple plantings at different elevations were attempted in the second and third year. Results of the three years' plantings will be discussed and guidelines for establishing aquatic plants in lakes and reservoirs will be provided.

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Session V: Federal, State, and Local Aquatic Plant Management Efforts

Aquatic Plant Management on the St. Johns River

Nancy P. Allen
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The St. Johns River is the longest river in Florida at 310 miles. The Corps of Engineers is responsible for aquatic plant management from Jacksonville to Highway 520 or approximately 200 miles. The St. Johns River is a complex and dynamic ecosystem. It is one of the few rivers in the United States that flows north. The width varies from a broad marsh at the headwaters, to large lakes in the central region, to more than 2 miles across in the northern reaches. The total drop of the river from beginning to end is less than 30 feet, or one inch per mile. This makes it one of the "laziest" rivers in the world.

Tributaries, springs, pollution sources, urban and agricultural impacts can be found along the river. The St. Johns River is a prime recreation site for boating, fishing, swimming, skiing, bird and manatee watching. It is also a federal navigation project with barge traffic on it. In today's society it is a challenge to balance these activities with aquatic plant management.

Since 1995, the Corps of Engineers has reduced *Pistia stratiotes* levels from 2,175 acres to 82 acres in 2000. *Eichhornia crassipes* levels have been reduced from 1,604 acres in 1995 to 70 acres in 2000. The implementation of a strict year round maintenance control program along with a public relations program are two of the major factors that have brought the St. Johns River's exotic plant levels to its lowest numbers in history.

The Oregon Aquatic Nuisance Species Management Plan

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Aquatic nuisance species (ANS) are nonindigenous species that threaten the diversity or abundance of native species, the ecological stability of infested water, or commercial, agriculture, aquacultural, or recreational activities dependent on such waters. The National Invasive Species Act (NISA) addresses ANS, authorizes state plan development, and funds implementation of state programs. Oregon has developed a management plan, produced by the Center for Lakes and Reservoirs at Portland State University in collaboration with a steering committee composed of members from federal and state agencies, universities, tribes and interest groups.

The plan identifies species to address, including zebra mussels, hydrilla, caulerpa and mitten crabs, and the strategies and actions the state should take to comprehensively address ANS impacts. The objectives of the plan are to: coordinate ANS management activities, prevent introductions, detect, monitor, and eradicate pioneering populations, control and eradicate established ANS, inform and educate the public and policy makers and to conduct research on management and control techniques. Recommended strategies to meet these objectives include the establishment of an Invasive Species Council, investigations of pathways of introduction, legislation to increases the state's authority to regulate the introduction of new species, implementation of a surveillance and early detection program, development of an integrated aquatic weed management program, education of user groups and research on management alternatives.

This plan will be presented to the Oregon Legislature and Governor for approval and funding. Followed by submission to the Federal ANS Taskforce for approval, which allows the state to receive federal funding for ANS activities.

Aquatic Plant Management Regulation in Michigan

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Michigan has been confronted with increasing pressure on its water resources over the past several decades due to unprecedented levels of development and recreational uses of inland lakes. Demands for aquatic plant management in these lakes, ranging from shoreline manipulation to the prevention and control of aquatic nuisance species, are increasing each year. Under the Public Health Code, 1978 PA 368, as amended, and the administrative rules promulgated thereunder, the Michigan Department of Environmental Quality, Inland Lakes and Wetlands Unit (ILWU), has the responsibility of reviewing permit requests for the application of chemicals to the surface waters of the state to control nuisance species, including aquatic plants and swimmer's itch. In addition, the ILWU is responsible for performing aquatic vegetation surveys,

compliance reviews and enforcement of permitted management activities, and evaluating new technologies for aquatic plant management. The increased pressure from development and recreation on Michigan's water resources has forced the ILWU to make significant changes in the way it regulates aquatic nuisance control activities, and poses many significant challenges for the years to come.

Aquatic Plant Management in Minnesota

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Minnesota's has abundant freshwater resources, some 10,000 to 15,000 water bodies. Tremendous pressure is placed on those resources to provide a wide variety of water recreation. The Minnesota Department of Natural Resources (Mn DNR) Aquatic Plant Management (APM) Program attempts to balance the needs of the riparian property owner for recreation while protecting aquatic plants for the many benefits they provide to Minnesota's lakes. Minnesota's APM regulations have been around for about 50 years. In Minnesota a permit is required to use herbicides for aquatic plant control in public waters and to destroy emergent vegetation. The use of a mechanical device known as the Crary WeedRoller® for aquatic plant control also requires a permit. A limited amount of mechanical aquatic plant control, cutting pulling or harvesting, is allowed without a permit in submerged and floating leaf vegetation. The most common method of aquatic plant control is spot treatment with aquatic herbicides. Submerged aquatic plants are the most common target of control efforts. The Mn DNR issues approximately 3000 APM permits per year to over 10,000 riparian property owners on about 875 lakes. The rules also prohibit some aquatic plant control activities. For example aquatic plant control in front of undeveloped shoreline is not permitted nor is the destruction of aquatic vegetation for esthetic reasons. The APM regulations play an important role in protecting aquatic habitats in Minnesota. In addition, a new effort aimed at restoring aquatic and shoreline vegetation is beginning to gather momentum.

Aquatic Plant Management in Iowa, 1993 to 2000

Gary S. Phillips
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Prior to the discovery of Eurasian watermilfoil (*Myriophyllum spicatum* L.) in 1993 in Crystal Lake, Hancock County, Iowa, no coordinated effort to manage aquatic vascular plants existed at the state level. Prompted by the discoveries of four additional Eurasian watermilfoil infestations, the Iowa legislature passed the Iowa Eurasian Watermilfoil Law in 1996 which called for the establishment of a state Eurasian Watermilfoil Program. Since implementation, this program has focused on public awareness and education, boat access monitoring, aquatic vegetation monitoring, management, and enforcement. As a result of Eurasian Watermilfoil Program activities, the number of known Eurasian watermilfoil infestations has increased to 16. Management plans were prepared for each of these infestations. As a result of the management plan review process, chemical treatment was determined to be the most suitable management practice for all waterbodies identified as infested with Eurasian watermilfoil. Chemical treatment was accomplished primarily through the use of the aquatic herbicide fluridone (*Sonar*). Complete eradication appears to have been achieved for seven of the 16 identified infestations. In 1999, the *Plan for the Management of Aquatic Nuisance Species* was submitted to the U.S. Fish and Wildlife Service. Notification of federal approval of the aquatic nuisance species management plan was received in January 2000. With federal support, Iowa has begun to take steps to develop an ANS program which will help coordinate the statewide management of aquatic vascular plants.

Aquatic Plant Management and Protection in Wisconsin

Frank J. Koshere
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Wisconsin is a water rich state with 15,000 inland lakes, thousands of miles of streams, and hundreds of miles of Great Lakes coastal shoreline. Native aquatic vegetation is common in many waters, and exotic species such as Eurasian Water Milfoil (*Myriophyllum spicatum*) and Curlyleaf Pondweed (*Potamogeton crispus*) are common. Historic plant control in the state dates to the late 1800's with the use of copper sulfate. Present plant management includes plant harvesting, winter and summer drawdown, biological control, bottom barriers, herbicide treatment, nutrient deactivation, and individual physical controls.

Current state statutes only partially regulate plant controls; specific statute and administrative rule presently cover only pesticide application. In fall 2001, Wisconsin anticipates a new state statute, which will provide broad regulatory oversight

on all forms of plant management in state waters, and will prohibit transport of problem species. A summary of the new legislation and potential changes in state regulation will be described.

Wisconsin also has a strong interest to protect native plant communities and restore native aquatic plants where lost from habitat change or exotic species. Restoration of near-shore terrestrial plants and of littoral zone plants is increasing as a management activity.

Wisconsin has a variety of state and local programs to regulate and fund Aquatic Plant Management and Protection. These programs provide state cost share to encourage development of plant management plans. State programs are administered by regional biologists. Control activities are most often proposed by local lake organizations and implemented locally.

Eurasian Watermilfoil in Minnesota: Where We've Been and Where We're Going

Chip Welling
Coordinator, Eurasian Watermilfoil Program, Minnesota Department of Natural Resources, Saint Paul, MN

Eurasian watermilfoil was discovered in Minnesota in 1987 when the plant was found in Lake Minnetonka, a large, heavily used lake on the edge of the Twin Cities. In Lake Minnetonka and nearby lakes, the exotic caused extensive and severe problems. Public concern led the Minnesota Department of Natural Resources (MnDNR) to attempt to prevent spread within the state and to initiate efforts to manage the plant. In spite of aggressive efforts to prevent its spread in Minnesota, by 1993 milfoil had been found in 68 bodies of water and has now been found in 121 bodies of water. Approximately 70% of the water bodies with milfoil are located in the Twin Cities region. Initial management by the MnDNR included efforts to eradicate the exotic or at least limit its distribution within individual lakes, but these did not succeed. Consequently, efforts shifted to management of problems, primarily interference with recreational use, caused by the plant. Away from the Twin Cities in greater Minnesota where there are few lakes with milfoil, the MnDNR continues to control milfoil in an attempt to limit further spread of the exotic. The MnDNR also has initiated and supported research in various areas to improve our understanding of the biology of milfoil and different approaches to management of the exotic. Options for future management of milfoil in Minnesota will be discussed.

NOTES

Session VI: All About Aquatic Plants In The Midwest

Biological Control of Purple Loosestrife in North America - An Emerging Success Story

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Purple loosestrife, *Lythrum salicaria* L., is an exotic perennial plant of European origin that is invading and degrading a variety of wet prairie and wetland habitats all across North America. Purple loosestrife can form dense monotypic stands replacing native plant species, thus, degrading food, shelter and nesting sites for wildlife. Currently there are no chemical or mechanical methods that provide long-term control of established stands of purple loosestrife. Biological control, the use of natural enemies to control a pest, is emerging as a successful long-term method of reducing impact of purple loosestrife on our native wetland environments.

Since 1992, four species of European insects, one root-mining weevil, one flower-feeding weevil and 2 leaf-feeding beetles, have been released in North America to control purple loosestrife. To date, more than 30 states are using biological control agents on purple loosestrife. Many of the insect releases made nationwide are successfully suppressing loosestrife infestations ranging from a few acres to over 20,000 acres in size. The introduction of these four insects will not eradicate purple loosestrife, but if successful, will significantly reduce its abundance within wetland habitats.

This talk will cover the national effort to establish purple loosestrife biological control agents in every state and provide a perspective on the success of biological control within Minnesota.

Control of Eurasian Watermilfoil Using Sonar Herbicide: Effects on Littoral and Pelagic Zone Foodwebs

Mary T. Bremigan[1], K .S. Cheruvelil[1], S. M. Hanson[1], V. O. Moore[1], K. L. Rogers[1], P. A. Soranno[1], R. D. Valley[1], and John D. Madsen[2]
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Submerged macrophytes are a major structuring feature of many lake littoral zones, and have the potential to strongly influence not only littoral zone foodwebs, but also pelagic foodwebs. In this study, we test the hypothesis that changes in submerged macrophyte communities, following herbicide control of an exotic macrophyte species, Eurasian watermilfoil (*Myriophyllum spicatum*), will lead to large changes in both pelagic and littoral foodwebs. We test this hypothesis through two whole-lake studies. In the first study, we measured both pelagic and littoral zone foodwebs in a reference lake and a lake treated with Sonar (5-7 ppb) before, during and after the treatment. In the second study, we evaluated pelagic and littoral foodwebs along a gradient of watermilfoil abundance in six lakes with contrasting densities of milfoil, due in part to Sonar treatments in three of the lakes one year prior to our sampling. In the pelagic zone, we measured zooplankton, nutrients, and algae. In the littoral zone, we measured macrophytes, zooplankton, fish and epiphytic macroinvertebrates. We found relatively large effects of changing macrophyte communities on both littoral and pelagicfoodwebs, although the strength of interactions varied with trophic level. Effects of macrophytes were strongest on littoral and pelagic zooplankton, adult fish, and water clarity. For example, for pelagic zooplankton, we found an increase in the largebodied Daphnia after macrophyte manipulation. These results show that changes in macrophytes due to invasion of an exotic macrophyte species, and its management, can lead to changes in both pelagic and littoral foodwebs.

Fluridone Herbicide Use in Minnesota for the Control of Eurasian Watermilfoil

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The Minnesota Department of Natural Resources (MnDNR) allocates staff time and funds for the control of Eurasian watermilfoil within the state. The goals of milfoil control are to reduce its impact within lakes where it occurs and to help prevent its spread to uninfested waters. Since 1987 when milfoil was discovered in Minnesota the MnDNR has made several attempts to control milfoil using the liquid formulation of fluridone (Sonar A.S. *). Early treatments were applied at target concentrations of 10 to 20 ppb and were done with the goal of milfoil eradication with little if any reduction in native non-target plants. In some lakes milfoil was reduced to below detectable levels for a few years but it eventually reappeared in those lakes. Those treatments also reduced the frequency of many native plant species. Based on those early treatments, in

1999 the MnDNR treated two lakes with 15 ppb fluridone in order to reduce milfoil to below detectable levels for at least three years. This was done to prevent the spread of milfoil to an uninfested area of the state and damage to native plants was considered acceptable. A recent Sonar A.S. * treatment of a Minnesota lake and evidence from Michigan indicate that fluridone treatments done at rates lower than those used previously in Minnesota can reduce milfoil abundance with little if any reduction in native plant species. Over the next four years the MnDNR plans to evaluate the potential to selectively control milfoil using 5-6 ppb fluridone.

Causes of Invasion and the Development of Management Strategies for Hydrophytes in Minnesota

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Strategies for limiting the spread and growth of invasive hydrophytes will be most effective if they are based on an understanding of why the taxon has developed invasive properties. Several theories have been advanced to explain aggressive growth during geographic expansion. First, growth is more favorable under new environmental conditions than those of resident locales. Second, herbivores may be absent in the new locale, resulting in populations allocating more resources to growth rather than defenses. Third, interspecific hybridization has occurred between a new taxon and one existing in an area resulting in nobel phenotypes with selective advantages in disturbed sites. Examples of all three invasive causes exist among Minnesota invasive species. A greater array of effective management strategies are possible if the nature of invasiveness is due to release from an environmental constraint, rather than the other two causes. Many of these potential solutions are limited by a need to implement water quality practices at the watershed or landscape scale. Well-developed biocontrol systems have been effective when release from herbivory is the causative agent. The products of interspecific hybridization pose the greatest dilemma for the development of effective management strategies. Competitive outcomes between indigenous species with introgressed invaders may be difficult to predict because hybrids possess novel traits. Furthermore, developing control measures that do not impact non-target cogeners may be impossible. Finally, geographic limits of hybrid taxa may be hard to ascertain because they can become locally adapted as they spread into new locales.

Managing Shallow Lakes and Deep-Lake Expectations

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Shallow lakes challenge lake managers because our models and experiences have been more aligned with deep lake systems. Now that management approaches for shallow lakes are being developed, lake managers face another challenge - that of deep-lake expectations. Many lake users and lakeshore owners want, and even expect, their shallow lake to have a sandy beach, big fish and be weed-free. Shallow lakes tend not to have these attributes.

As lake managers develop management approaches for shallow lakes, it is important to also understand, and to some extent, develop user expectations regarding desired outcomes. Because of deep-lake expectations, it is often assumed that the outcome of shallow lake management is a weed-choked lake where no boating is allowed and no swimming can occur.

A case study will be used to illustrate some tools for getting past deep-lake expectations and managing appropriate uses for a shallow lake. I will also give some thoughts about research and management needs.

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Session VII: Select Biological Case Studies

Mangrove Restoration for Sustainable Fish Pond Production: A Case Study in the Northern Coast of Java Island

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Mangrove ecosystems along the northern coast of Java Island, Indonesia, have long been under human pressure due to their conversion into fish or shrimp ponds. However it has been realized that the productivity of these ponds is only high at the beginning, but later on declines to the extent that the ponds become abandoned. The reduction of the ponds productivity seems to be related to low organic or nutrient input to the ponds. A program of mangrove restoration has been carried out by planting two common species of mangrove, namely *Avicennia marina* (Forsk.) Vierh., and *Rhizophora mucronata* Lamk. We evaluated the restoration program by measuring the growth of the plants including their height, diameter of stem and canopy, and regeneration rate by counting the number of seedlings and saplings. We also measured the production and decomposition rate of litter from the two species. *A.marina* showed better growth and rate of regeneration than *R. mucronata*. However, *R. mucronata* showed higher litter production and rate of decomposition compared to *A. marina*. The planting of the two species for mangrove restoration showed significant success along the northern coast of Java. We recommend that at least 400 m should be preserved as a mangrove green belt along the coast of Java to support sustainable fish or shrimp production from the ponds. In fact, mangroves grew better in areas close to the ponds since the ponds provide better water availability, substrate texture and mineral content.

The Response of Largemouth Bass to Applications of Aquathol K in Lake Seminole, Georgia

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Largemouth bass (*Micropterus salmoides)* population characteristics were compared between coves treated with Aquathol K to reduced hydrilla (*Hydrilla verticillata)* and untreated control coves. Population characteristics included abundance, growth, and length structure of young fish, and adult (> 25 cm) abundance, body condition, and length structure. Treatments with Aquathol K were successfully at hydrilla reduction, but hydrilla was not eliminated and some native plants became established. At age-0 for the 1999 and 2000 year-classes, electrofishing catch-per-effort (CPE) for number and weight were similar between treated and control coves. However, age-0 fish were larger, hence growth was faster in coves treated with herbicides. By age-1 for the 1999 year-class, CPE was greater for both number and weight in treated coves than in untreated coves. Age-1 fish maintained their size advantage in the herbicide treated coves. Using a catch-depletion technique in spring 2000, adult largemouth bass density and biomass were similar in a cove treated with Aquathol K compared to an untreated cove. However, body condition for fish greater than 38 cm was higher in the treated cove. Prior to spring 2001, Aquathol K was applied to the same treatment cove and adult density was 36% higher in 2001 compared to 2000. Multiple treatments of Aquathol K to reduce hydrilla had no adverse impact on young or adult largemouth bass population characteristics. In some instances, positive effects on the population were detected.

Economic Value of Aquatic Vegetation to Fisheries: Economic Impact of Increased Aquatic Plants at Two Lakes (WU 33307)

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This work evaluates the economic impact that the level of aquatic vegetation has on various activities that take place at large impoundments. User groups such as anglers and boaters are being studied, with the initial focus on anglers. During 2000, questions pertinent to economic impacts were added to creel surveys undertaken at Lakes Murray and Moultrie, South Carolina. Management of hydrilla (*Hydrilla verticillata)* is the current concern at both lakes. Data on some angler trip expenditures (food, bait, gas, lodging, non durable goods) were already collected as part of the original creel survey. In addition, anglers were asked to state preferred level of aquatic plants (same, more, or less than existing conditions). Fishing use (number of days fishing) at varying levels of aquatic plants was obtained by asking anglers to state their use for existing conditions, historic high plant conditions, and an intermediate level (half historic high). Based on preliminary data (2 months), average trip expenditures ranged from $53 for day use bank anglers at Lake Moultrie to $279 for overnight boat anglers at Lake Murray; anglers with boats and overnight visitors incurred greater expenditures. An economic impact model was developed for the region around the lakes. Compared to Summer 2000 plant conditions, annual fishing would double if

vegetation returned to previous high levels. As an example, Lake Murray anglers interviewed in May and June 2000 reported 10,800 annual visits, expending $747,000. That spending level supported or resulted in $288,000 in local income and 14 annual jobs. If vegetation increases to historic high levels, visits would increase to 20,400, income to $1.2M, and jobs to 60. The amount of plants in Lake Murray for July and August 2000 is preferred by 51% of the anglers, 36% preferred more and13% preferred less. From these analyses, it is clear that preference information can be obtained for plant control decisions, and that the effects on local economies can be evaluated. Complete annual angler use, plant preferences, and local economic values will be available for 2000-2001 in late summer.

Shear Stress and Sediment Resuspension in Canopy- and Meadow-Forming Submersed Macrophyte Communities (WU 33128)

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We examined the impacts of macrophyte beds dominated by a canopy-forming (*Myriophyllum sibiricum*) and a meadow-forming (*Chara canescens*) species on shear stress near the sediment interface and resuspension in shallow Lake Christina, MN. Studies were conducted in late summer, 1998, when macrophyte biomass levels exceeded 200 g m^{-2}, and in early summer, 2000, when biomass was greatly reduced (< 20 g m^{-2}) in both plant beds. The critical shear stress (τ_c) of sediments, measured experimentally in the laboratory, was low (1.6 dynes/cm^2) indicating a strong potential for resuspension at moderate wind speeds in the absence of submersed macrophytes. During 1998, *in situ* turbidity was low at both the *M. sibiricum* and *Chara* station and rarely increased when calculated bottom τ exceeded τ_c, indicating that both macrophyte beds were effective in preventing sediment resuspension in the lake at these high biomass levels. Apparent measured τ, measured via gypsum sphere dissolution, did not exceed τ_c above the sediment interface in either plant bed during the study period in 1998. In contrast, sediment resuspension occurred in both plant beds during similar high winds in June, 2000. However, apparent measured τ was lower that calculated bottom τ, suggesting that even at very low biomass levels, macrophytes in both plant beds were having some impact on τ. Information obtained from these two general biomass levels and architectural types (i.e., canopy versus meadow) may be used to modify resuspension models to account for the impacts of macrophyte communities on bottom shear stress and sediment resuspension in shallow systems.

Managing Curlyleaf Pondweed and Eurasian Watermilfoil Without Herbicides

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In Minnesota, two exotic aquatic plants can grow to nuisance conditions and hamper lake use. One of the plants is curlyfeaf pondweed. Several years ago, laboratory experiments indicated curlyleaf pondweed would not grow back if it was cut close to its base after reaching the 15th node. Field observations found turion production did not generally occur until the 22nd node. Because nearly all new growth arises from turions, when volunteers cut plants within the 15 to 22 node stage, curlyleaf growth was curtailed and its density was found to diminish after several years of "pre-emptive" cutting.

Eurasian watermilfoil does not become a nuisance in every lake it invades. We have been working with the nitrogen threshold concept that allows us to zero in on problem milfoil areas. By sampling lake sediments for nitrogen, we can delineate areas of potential nuisance milfoil growth. At low nitrogen levels (less than 3 ppm as exchangeable ammonia), milfoil can grow but generally not to nuisance conditions. At high sediment nitrogen levels, milfoil has the potential to top out unless some other variable is limiting. When we concentrate our deep cuts and harvesting control efforts on the nuisance areas and let the other non-nuisance areas to, it saves money and minimizes lake impacts.

Barley and Bacteria: What Have We Learned?

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We have conducted studies on the use of decomposing barley for algae control for the past 3 years. In addition, we conducted several tests last summer on the use of a bacterial product to compete with algae for nutrients. In both cases, our results have been inconsistent. Most of the tests suggest no effect, although in each case we had at least one test that indicated some control might have been achieved. Another study on barley conducted at the University of Nebraska also was

negative although that study is continuing into this summer. Studies conducted in ponds in Ontario from 1991 to 1995 suggested that barley was an effective control agent for algae. Unfortunately, large scale research on barley in the U.S. may have to be curtailed because EPA considers barley to be a pesticide. Field testing of pesticides, without an EUP, is limited to no more than a total of 1 acre of water. To our knowledge, studies conducted at other research institutions on the use of bacteria have not shown positive results.

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Session VIII: Aquatic Herbicides And Surfactants – Chemical Studies

New Approach to Long-Term Control of Curlyleaf Pondweed

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Curlyleaf pondweed (*Potamogeton crispus*) has become a wide spread problem in many northern lakes, and in some situations can be a worse problem than Eurasian watermilfoil (*Myriophyllum spicatum*). Failure of herbicide applications to achieve long-term control has largely been attributed to applying the herbicide after curlyleaf pondweed has formed turions. Outdoor mesocosm studies conducted at the U.S. Army Corps of Engineer, Lewisville Aquatic Ecosystem Research Facility (LAERF) in Texas demonstrated that applying Aquathol K (1 mg/L active ingredient (ai) dipotassium salt of endothall) to curlyleaf pondweed late in its life cycle, but prior to turion formation, showed significant initial biomass reduction. However, most plants recovered and formed turions following this treatment scenario. Curlyleaf pondweed treated in early spring, as water temperatures reached or exceeded 15°C and new growth began, resulted in better control with significantly less recovery than compared to other treatments. Small-scale greenhouse studies conducted at the LAERF to evaluate the effect of water temperature on Aquathol K efficacy showed that the product is less effective at cold temperatures ($\leq$ 15°C). Based on these results, a field study was conducted to demonstrate improved long-term control of curlyleaf pondweed using Aquathol K and to document the treatment effect on water quality. Five lakes infested with curlyleaf pondweed were selected in Eagan and Plymouth, Minnesota. Three lakes were treated with Aquathol K in early spring when water temperatures first exceeded 15°C. Two lakes were treated with an application rate of 1.5 mg/L ai and one with an application rate of 2.0 mg/L ai. Two additional lakes were monitored as untreated references. Plant evaluations and water quality data were collected pretreatment and periodically through one year after treatment. Herbicide treatments were successful at controlling curlyleaf pondweed biomass prior to turion formation. Water quality monitoring showed no significant effects on dissolved oxygen, pH, or conductivity. Herbicide treatments and monitoring will be continued for an additional 1 to 2 years to determine if the turion population can be fully depleted and curlyleaf pondweed eliminated.

Use of Plant Assay Techniques to Screen for Tolerance and to Improve Selection of Fluridone Use Rates

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The herbicide Sonar (active ingredient fluridone) is a valuable tool for selectively controlling exotic aquatic plants such as hydrilla (*Hydrilla verticillata* (L.f.) Royle), Eurasian watermilfoil (*Myriophyllum spicatum* L.) and Egeria (*Egeria Densa*). Last year we reported on differential tolerance of some hydrilla populations in the state of Florida. While increased tolerance has been suspected by some lake managers, quantitative laboratory evidence now substantiates a differential susceptibility of hydrilla to fluridone in several aquatic systems in the state of Florida. The ability of a clonal aquatic plant to develop tolerance to herbicides was unexpected and is a significant new development in aquatic plant management. In addition to sampling of hydrilla, SePRO has begun evaluating various populations of target exotic (Eurasian watermilfoil, Egeria, monoecious hydrilla) and native (elodea, coontail, milfoils, pondweeds) plants to determine comparative susceptibility to fluridone. Recent sampling of Eurasian watermilfoil in the northern United States suggests that prior treatments may play a role in differential susceptibility to low rate fluridone treatments. A plant assay originally developed for research purposes has been modified and proven to be an excellent predictive tool for quantifying the response of hydrilla, Eurasian watermilfoil, Egeria, and various native plants to fluridone exposure. This assay called the PlanTEST™ can be used proactively to screen for populations with increased tolerance and to determine the level of fluridone necessary to elicit a phytotoxic response for a target population. In addition, the use of biochemical monitoring of the vegetation (EffecTEST™) in conjunction with the FasTEST immunoassay provides a mechanism for evaluating the status of a treatment over time. This data has been used to make several decisions on whether or not additional applications are necessary.

Renovate: Finally in the EPA Cue and Under Review

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The data package for Renovate (a.i. triclopyr) is currently under EPA review and a decision for aquatic registration is expected in 2001. The decision to cancel the Renovate EUP in the early summer of 2000 was tied to the fact that a registration decision was pending. Unfortunately, the length of the cancellation has delayed further field development work through the summer of 2000 and 2001. Nonetheless, recent research data suggests that Renovate will have a good fit in the aquatic market. Renovate continues to show great promise as an integrated control tool for Purple loosestrife due to its excellent selectivity and compatability with biological control organisms. Data from Minnesota field trials suggests that Renovate use rates as low as 0.5 mg/L can provide excellent selectivity as well as good seasonal control of Eurasian watermilfoil when applied to small treatment blocks in large water bodies. Moreover, initial and ongoing field trials on the exotic plant Parrotfeather in California suggest that sequential low rate treatments may enhance control due to increased translocation of the herbicide. Upon receiving an EPA label for treating aquatic sites, trials are planned for Hygrophila, Limnophila, Limnobium, and several other nuisance aquatic plants.

Herbicide Evaluation Against Giant Salvinia

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Giant salvinia (*Salvinia molesta* D. S. Mitchell) is an aggressive, free-floating, aquatic fern that has recently established and become a nuisance in many lakes, rivers, and reservoirs in the United States. Current information on the use of aquatic herbicides to manage this exotic species is limited. An outdoor tank study was conducted at the Lewisville Aquatic Ecosystem Research Facility, Lewisville, TX to assess the efficacy of the following treatments against giant salvinia: Rodeo (glyphosate), Clearigate (copper), Rodeo + Hydrothol 191 (dimethylalkylamine salt of endothall), Rodeo + Reward (diquat), and Rodeo + Clearigate. Rate of application and surfactant use varied with treatment. Regardless of surfactant type (organosilicone blend vs. non-ionic), surfactant combination, or rate of herbicide application (4.5 to 18.0 kg ae ha^{-1}), Rodeo controlled 95 to 100% salvinia 42 days after treatment (DAT). Combining low rates of Rodeo with other herbicides (Clearigate, Hydrothol 191, or Reward) was also effective against salvinia. Clearigate applied at rates as low as 1.4 kg ha^{-1} significantly reduced salvinia dry weight biomass compared to untreated plants, however regrowth of surviving plant tissues was evident. Higher rates (10.4 to 13.8 kg ai ha^{-1}) of Clearigate were required to minimize regrowth and to maintain $\geq$ 70% control of salvinia 42 DAT.

Herbicide Evaluation for Control of *Cabomba caroliniana* and Subsequent Impact on the Non-Target Species, *Megalodonta beckii* (WU 33199)

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Cabomba caroliniana Gray. (cabomba) is a rooted, submersed perennial commonly found in stagnant to slowflowing waters. Cabomba can be a persistent and competitive plant, forming dense, monotypic stands which can displace other established native plant species. In Connecticut, cabomba populations threaten the survival of *Megalodonta beckii* (Torr.) Greene (water marigold), a state-listed threatened aquatic plant. Updated information on the selective use of herbicides to control nuisance cabomba populations while minimizing injury to nontarget plants was needed. A growth chamber study was conducted to evaluate the effect of fluridone concentration on the growth of*Cabomba caroliniana* Gray. (cabomba) and *Megalodonta beckii* (Torr.) Greene (water marigold). A separate growth chamber experiment was conducted to determine the efficacy of 2,4-D and triclopyr for control of cabomba. None of the herbicide rates evaluated in this study were effective in reducing cabomba shoot mass, compared to untreated controls.

Polymers 2001

Stephen P. Brewer
Brewer International, Vero Beach, FL

Spray adjuvants include wetting and penetrating agents, buffering agents, stickers, defoamers and drift control agents. Drift control agents include polymers, invert oils, and thinverts. The building block for every spray adjuvant is the surfactant portion. There are three types of surfactants, nonionic, cationic and anionic. The surfactant lowers surface tension spreading the spray droplet across the surface. Polymers contain some surfactant but their main purpose is for drift control, sinking, sticking and water clarity. Brewer International has a full range of products in 2001 that include Poly Control, Poly Dry, Poly An and Poly Clear. Poly Clear our newest entry replaces alum treatments in clearing up pond sediments. Brewer has on going trials with Cygnet and UAP-Timberlands that will be updated during the meeting.

Surfactant Effects on Copper Herbicide Uptake in Submersed Weeds

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Surfactants are "surface active" agents that reduce surface tension and increase spray wettability, and are the active ingredient in many adjuvants. While a significant database has been generated on the use of surfactants in terrestrial weed control and emergent and floating leaf aquatic plants, little published information is available on effectiveness of surfactants for submersed weed control. The main reason for using a surfactant for submersed weed control would appear different than terrestrial applications since submersed plants do not have a waxy cuticle, plant leaves are only a few cells thick, and there is no need to decrease surface tension since it is being applied in a water medium. There are several reports from professional applicators indicating improved efficacy on certain submersed plant species when using a surfactant with contact herbicides. Whether the surfactant combination is increasing herbicide uptake by facilitating penetration or by increasing exposure through adherence is undetermined.

The high cost of aquatic herbicides and the demand by public and regulatory agencies to use the lowest effective herbicide concentrations has increased interest in surfactant use. The use of an effective surfactant could increase herbicide effectiveness and predictability, make a herbicide more broad spectrum, reduce rates, and reduce cost, however no quantitative data has been presented to support surfactant use in submersed weed control. Preliminary results from surfactant/copper herbicide combinations for the control of submersed plants will be presented.

Herbicide Combinations and Interactions (WU 33304)

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Small-scale studies were previously conducted to evaluate Aquathol K (dipotassium salt of endothall)when used in combination with either Reward (diquat dibromide), Cutrine-Plus (chelated copper), or Hydrothol 191 (dimethylalkylamine salt of endothall), for improved control of hydrilla (*Hydrilla verticillata* (L.f.) Royle). Results showed that low application rates of Aquathol K (1 mg/L active ingredient (ai)) combined with either Reward (0.5 mg/L ai), Cutrine-Plus (0.5 mg/L ai), or Hydrothall 191(0.2 mg/L ai) improved control of hydrilla compared to use of the product alone. Based on the previous small-scale studies, a large-scale demonstration was then conducted on Toledo Bend Reservoir, Louisiana to verify herbicide combinations for improved control of hydrilla. Herbicide treatments included Aquathol K combined with either Reward, Cutrine-Plus, or Hydrothol 191 and were applied to two-hectare plots. Applications were conducted on 8 and 9 September 1999 using a dual tank application system, when hydrilla biomass was at its peak, topped out, and coated with algae (worst case). The lowest combination rates of Aquathol K (1.5 mg/L ai) + Reward (1 gal/acre, ~ 0.25 mg/L ai), Aquathol K (1 mg/L ai) + Cutrine-Plus (0.5 mg/L ai), and Aquathol K (1 mg/L ai) + Hydrothol 191 (0.2 mg/L ai) resulted in 90 to 95% control of hydrilla at 8 weeks after treatment. Biomass evaluations conducted in August 2000 showed that plots treated with the lowest combination rates continued to exhibit good hydrilla control one year after treatment. Additional small-scale studies will be conducted in the spring of 2001 to evaluate herbicide compatibility when mixed in single tank application systems.

Concentration/Exposure Time Relationships for Fluridone to Control Eurasian Watermilfoil

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Concentration/exposure time relationships were investigated for the AVAST!® formulation of fluridone against the target plant Eurasian watermilfoil (*Myriophyllum spicatum*) in a controlled-environment growth chamber. Application rates tested were 0, 10, 20, 40, and 80 μg L^{-1} active ingredient (ai) fluridone, with exposure times of 45 and 90 days. Elevated concentrations of the phytoene pigment indicated the presence of fluridone in plant tissues 7 days after treatment (DAT); pigment concentrations ranged from 68 to 105 μg g^{-1} fresh weight (FW) for treated plants versus a concentration of 12 μg g^{-1} FW for the reference. All rates were effective in significantly decreasing total chlorophyll and beta-carotene concentrations in milfoil apical shoots as early as 7 DAT. Plant injury was sustained throughout the study as evident in a 90% reduction in shoot biomass during a 45-day exposure. Following the 90-day exposure, shoot biomass decreased by 99%. There were no significant differences between application rates for either exposure period (p=0.05). Results from this small-scale study indicate that the AVAST!® formulation of fluridone was very effective in controlling milfoil.

Levels of Fluridone in Interstitial (pore) Water at Clear Lake, CA Following Applications for Eradication of Monoecious Hydrilla (*Hydrilla verticillata*)

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Sonar has been applied to in specific areas to eradicate Monoecious hydrilla in Clear Lake, CA since 1995. The slow release pellet (SRP) formulation has been applied during the growing season (May to October) either weekly or twice per week in some sites for the past 6 years whereas a few new sites have been only treated since 2000. We used a dual-compartment Plexiglas sampler fitted with dialysis membranes to compare levels of fluridone in the upper 5-10cm of sediment and in the water immediately above (5 cm) the sediment in three sites: a control (untreated) site, a site having been treated for 5 years and a site pre- and post first year's treatment. Sediment pore water and adjacent column water had no detectable fluridone or <0.5ppb in the control site and pretreatment site. Fluridone levels in pore-water in treated sites were highly variable and ranged from <.4ppb to 41ppb and in the (bottom) column water from 3.8 to 177ppb. Inasmuch as (1) physical distribution of pellets is patchy and (2) each pellet generates a well-defined point from which fluridone diffuses, the large variations in pore-water levels are not surprising. However, these data suggest the need for a closer examination of actual exposure to fluridone at the pore-water/sediment/water interface as well as the need to optimize pellet geometry and loading for more uniform distribution.

Selective Control of Eurasian Watermilfoil Using Fluridone (WU 32841)

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A new formulation of fluridone , AVAST!®, was evaluated to determine application concentrations and exposure times required to control Eurasian watermilfoil (*Myriophyllum spicatum*) and to evaluate its potential selectivity in a northern native plant community. The study was conducted in an outdoor mesocosm system located at the USAERDC Lewisville Aquatic Ecosystem Research Facility in Texas. Five species were evaluated including Eurasian watermilfoil, Illinois pondweed (*Potamogeton illinoensis*), sago pondweed (*Potamogeton pectinatus*), wildcelery (*Vallisneria americana*), and elodea (*Elodea canadensis*). Depending on species, apical tips, tubers, or rooted plants were planted in 8 L plastic containers filled with sediment. Eleven containers per species were placed in each tank, and plants were grouped by species. Plants were grown for 6 weeks before treatment. Application rates included 0, 5, 10, and 20 ug/L active ingredient (ai) fluridone. Exposure time was 60 days, and biomass was harvested at the end of the 60-day treatment period. Eurasian watermilfoil biomass was reduced by 86% at an application rate of 5 ug/L and 93% at 10 ug/L compared to the untreated reference. Biomass from the four native species was not significantly reduced at a rate of 5 ug/L compared to the untreated reference. Sago pondweed and Illinois pondweed biomass were reduced 20 to 60% compared to untreated controls at 10 and 20 ug/L, but were not eliminated. Elodea and wildcelery biomass were not significantly reduced at any application rate.

Endothall Field Trials for the Control of Hydrilla and Ceratophyllum in New Zealand

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The exotic submerged species *Ceratophyllum demersum*, and *Hydrilla verticillata*, cause localised problems in lakes, rivers and drainage channels in New Zealand. Recent mesocosm trials have shown the potential of endothall to control both of these species. During the summer of 2000-2001 endothall was applied in two field trials toevaluate its efficacy on hydrilla and ceratophyllum. In Lake Waikapiro hydrilla beds were treated at one of two rates of Aquathol K and in the Wairarapa ceratophyllum in drainage channels was treated at one of three different rates. Results indicate notable decline in both hydrilla and ceratophyllum weed beds where product contact was maintained.

Using Barrier Curtains to Isolate Eurasian Milfoil Treatment Areas During a Sonar Herbicide Application

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Eurasian Milfoil has plagued the waters of the North America for a number of years, it is probably the major aquatic weed problem that aquatic plant managers face. The federal government has classified this plant as a "Harmful nonindigenous species" and most states recognize the threat this weed poses to the aquatic environment.

Sonar Aquatic Herbicide has a proven track record of controlling and in some cases eradicating Eurasian Milfoil from our nation's waterways. In some situations however, Sonar has not been considered because of the long contact exposure time requirement. In order to provide this control, the plant must be exposed to low doses of the herbicide for an extended period of time, up to 8 weeks in some studies. As herbicides tend to dilute out of treatment areas, this technology has been most effective when used as a whole lake treatment. Under that type of application, the concentrations remain within the proper range throughout the lake. In large lake systems, this is a cost prohibitive approach in some cases.

During the summer of 2000, AquaTechnex biologists deployed a unique barrier curtain technology to segment a 167 lake into treatment and non-treatment areas. Eurasian Milfoil was present in the lake and dominated the north and south coves. The remainder of the shoreline had not yet been infested. The barrier curtain was designed to be non permeable. Two curtains were deployed. The north barrier was approximately 900 feet in length and isolated a treatment area of about 5 acres. The south barrier was approximately 2,300 feet in length and isolated just over 20 acres. Sonar was applied and maintained behind these barriers using 5 split applications spaced at two-week intervals.

Over 200 FasTEST samples were collected both in and outside the treatment areas from 13 sampling sites. The FasTEST data was used to monitor conditions and maintain Sonar levels in the treatment areas. It also was used document the levels outside the curtain.

This project resulted in excellent control of Eurasian Milfoil in these isolated areas of the lake. The FasTEST data confirmed that these barriers could be used to segment the lake into treatment and nontreatment areas. There was little or no Sonar detected outside these isolation areas and no impact on aquatic vegetation outside the treatment areas.

This technology will allow lake managers to target Eurasian Milfoil in large lake and river systems or protect native aquatic plants in the nontarget portion of the lake.

NOTES

Session IX: Quantification and Monitoring Aquatic Plants

An Evaluation and Comparison of Methods for Estimating Whole Lake Submersed Macrophyte Occurrence and Abundance

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Gathering accurate data on whole lake submersed macrophyte occurrence and abundance can be costly and time consuming. We evaluated several approaches to assess macrophyte abundance and estimated sample sizes needed for field surveys. Quantitative biomass (n>40) and relative density measurements (0-5 rating, Jessen and Lound 1962) using a hook or rake (n>99) were obtained from each of three shallow (<3m, 57-1,619 Ha) lakes in Minnesota. Relative density was related to biomass for common species but the fit was poor and varied among lakes. There were no differences between hook and rake density estimates for seven of the eight most abundant species. There was no difference between our hook densities (n=105) and rake densities (n=35) collected in the same lake by the Minnesota DNR for the six most abundant species. Sample sizes needed for standard errors of Y% of the mean were calculated from current and historical data from 47 lakes (N= S2/(Y)2*X2). At lower frequencies (<60%) and relative densities (<2), sample sizes required decreased logarithmically with frequency of occurrence and density. At higher densities or frequencies, sample size needed decreased sharply; for the most common species 10-15 samples were adequate for 10% error. The Jessen and Lound relative density method is robust and yields consistent results, but is not a precise predictor of biomass. Estimates of relative density can be obtained with a reasonable number of samples for abundant species, however for less abundant species very large sample sizes (100-5,000) are required.

Upper Mississippi River Aquatic Plant Quantification for Natural Resource Management

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The Long Term Resource Monitoring Program (LTRMP) is a partnership between the
U.S. Army Corps of Engineers, the United States Geological Survey, and the five Upper Mississippi River states (Illinois, Iowa, Minnesota, Missouri, and Wisconsin). The purpose of the LTRMP is to document and explain long-term biological, physical, and chemical changes in the Upper Mississippi River System and provide this information to river managers. Since 1998, the vegetation component of the LTRMP has been monitoring submersed aquatic vegetation (SAV) in Navigation Pool 4 using stratified random sampling. In each of the last three years, SAV samples were collected with a doubleheaded garden rake within shallow aquatic areas
(<= 3 m). A minimum of 550 randomly distributed sites was dispersed into nine habitat strata. The aquatic vegetation parameters measured included substrate, depth, and species presence. An index of abundance for each species was developed from the quantity of vegetation found on the sampling rake. The data enabled us to construct a profile of SAV in each habitat stratum and in the entire navigation pool. Emergent vegetation data has been monitored annually via interpretation of color infrared photos (1:15,000). Once each species cluster or vegetation type is delineated, the interpreted photo is digitized and transferred into GIS coverage maps. From these maps, successional changes can be monitored.

Submersed Aquatic Vegetation Early Warning System (SAVEWS): Technology and Operational Status (WU 33118)

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Rapid and accurate measurement of the abundance and distribution of submersed vegetation has been achieved with the ERDC-developed Submersed Aquatic Vegetation Early Warning System (SAVEWS). The system consists of offthe -shelf commercially available digital hydroacoustic, global positioning system, and PC components. Data are post processed with an ERDC-developed and patented digital signal processing code. The system has been tested on most commonly occurring freshwater and estuarine species of submersed vegetation in the
U.S. Numerous agencies in addition to ERDC are independently using the system for various resource and nuisance plant assessments. The SAVEWS patent has been licensed to Biosonics, Inc. (Seattle, WA), which now handles all distribution, training, and technical support. Research and development continues at ERDC to extend the performance and capabilities of the system. In this presentation the basic working of SAVEWS, it's various uses and users, and developmental research are described.

Use of Remote Sensing and Hydroacoustic Approaches for Integrated Assessment of Submersed Aquatic Vegetation (WU 33127)

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Hydrilla infestation in sections of Lake Seminole, a 37,500-acre reservoir along the Florida-Georgia border, was studied through aerial and satellite image analysis and advanced hydroacoustic survey. Image analysis delineated openwater and four classes of aquatic vegetation: dense submersed, sparse submersed, floating, and emergent. In comparisons with ground-reference information collected specifically to evaluate image data, areas with dense submersed, emergent, or floating vegetation were correctly identified better than 95% of the time using true-color aerial imagery (ground resolution = 1 m) or multispectral satellite data (4m resolution). However, sparse and open areas within and around dense submersed growth were accurately differentiated less than 50% of the time. The raster-based approach used in satellite image interpretation provided better resolution and greater overall accuracy (15% difference) than the vector-based aerial method. Comparisons with results of other field surveys (species presence / absence and biomass sampling) showed 73-100% accuracy for detection of submersed vegetation. Hydroacoustic measurements produced plant height and coverage data for 5 study transects (10-meter resolution). Plant biovolume calculations from height and coverage indicated that almost 50% of the water volume of the study area contained submersed vegetation. Dropouts and similar sharp spatial changes in plant architecture detected hydroacoustically were clearly visible in enhanced true-color satellite imagery. Overall, results show good accuracy and excellent detail for quantification of submersed vegetation using remote sensing and hydroacoustic assessment technologies.

Databases for Determining Long-Term Trends in Aquatic Plant Communities

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If you do aquatic plant management you get calls every year that "The weeds in my lake are worse than ___ (pick your number) years ago. What can I do?" How much is fact and how much is selective memory? At the Wisconsin Geological and Natural History Survey I developed databases of lake plant surveys from the scientific literature, and from historical and current resource management surveys to answer these questions and to determine longterm trends in aquatic plant community composition. The databases include information for 900 lake-year combinations for 568 lakes. Many, especially older, surveys are floristic lists, sometimes with a qualitative statement of abundance. More recently, frequency surveys are more common. Biomass surveys are rare. The databases include 438 lakes that were sampled only once; 96 that were sampled two to four times, and 34 that were sampled five or more times. Of the lakes that were sampled more than once, 42 had less than five years between the earliest and latest sampling date, 27 were between six and ten years, 21 between 11 and 20 years, and 29 over 20 years - the longest was 68 years. These data are stored in Paradox databases and two indices of biological integrity, the Floristic Quality Index (FQI) that uses floristic data, and the Aquatic Macrophyte Community Index (AMCI) that uses frequency data were developed to analyze trends. Example applications are given using the indices and the databases to show management applications.

Plant Quantification for Minnesota's Statewide Lake Assessment

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The Minnesota Department of Natural Resources (MnDNR) Fisheries, Division is responsible for fisheries' habitat management on thousands of Minnesota lakes. Fisheries biologists collect information on macrophyte communities in about 150 different lakes each year. Because of high number of lakes surveyed, a rapid, mostly qualitative survey method is currently used.

Quantitative data on plant species distribution, abundance and composition are needed to adequately describe, monitor and assess change in macrophyte communities. This study compares the current qualitative transect method used by MnDNR Fisheries with a quantitative point survey method. This point survey provides a relatively rapid method for nonbotanists to collect non-biased, quantitative plant data from a boat surface.

Results indicate that the point survey method provides more accurate estimates of species frequency than did the transect survey. Data from the point survey also provide estimates of percent of littoral zone with vegetation, assessment of species occurrence and abundance at different water depths, and the ability to map various plant community types and depth contours within a lake.

This point survey method was evaluated on four lakes with different aquatic macrophyte community types: 1) a shallow, algal dominated lake with sparse rooted vegetation, 2) a wild rice dominated lake, 3) a lake with an abundant and species rich macrophyte community, 4) a lake with an endangered aquatic plant species. Recommendations are given for sample placement, minimum sample number and sample plot size. The time required to complete the survey in different lake types is also discussed.

Quantification of Aquatic Plants in Two Vermont Lakes for Evaluation of Whole-Lake Treatments with Fluridone

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We are studying the aquatic plant communities of Burr Pond and Lake Hortonia, VT, as part of a whole-lake application of fluridone for Eurasian watermilfoil control in both lakes. The lakes were treated in June of 2000 with a target of 6 ppb SONAR A.S. The plant communities were evaluated in 1999 (pre-treatment) and 2000 (year of treatment), using point intercept, biomass, and line intercept transect methods. Species frequency of occurrence data were obtained at 299 points for Lake Hortonia and at 191 points for Burr Pond in June and August of each year. Biomass samples were collected at 30 random points for each lake for June and August of each year by SCUBA from within a 0.1m^2 quadrat. Samples were sorted to species and dried to constant weight at 55 C. One wetland line intercept transect in each lake was evaluated in August of each year. The Lake Hortonia wetland transect was 200m long, while the Burr Pond transect was 80m long, with transects having one-meter intervals. The most common species in Lake Hortonia was Eurasian watermilfoil, with a frequency of 60.5% in June 1999, 54.8% in August 1999, 56.8% in June 2000, and 44.8% in August 2000. Eurasian watermilfoil was the most common plant in Burr Pond, with relative frequencies of 67.5% in June 1999, 57.6% in both August 1999 and June 2000, and 40.8% in August 2000. Eurasian watermilfoil biomass in Lake Hortonia was 254 gm^{-2} out of a total biomass of 336 gm^{-2} (June 1999); 285 gm^{-2} out of 363 gm^{-2} (August 1999); 172 gm^{-2} out of 206 gm^{-2} (June 2000); and 34.0 gm^{-2} out of 51.0 gm^{-2} (August 2000). The Eurasian watermilfoil biomass in Burr Pond was 142 gm^{-2} out of a total biomass of 209 gm^{-2} (June 1999); 49.0 gm^{-2} out of 94 gm^{-2} (August 1999); 39.0 gm^{-2} out of 86.0gm^{-2} (June 2000); and 3.0 gm^{-2} out of 37.0 gm^{-2} (August 2000). The one-year posttreatment plant community will be evaluated in June and August of 2001. The resulting aquatic plant community quantitative data for these two lakes will provide a sensitive indicator of the selectivity of fluridone.

Notes

Session X: Biological Aquatic Plant Control

Population Management of Triploid Grass Carp (WU 33200)

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This study is comprised of three elements designed to enhance the utility of triploid grass carp as a management tool for aquatic vegetation. The elements include population assessment and modeling in large water bodies, telemetry studies in a coastal river to study emigration potential into estuarine areas, and determining the feasibility of injectable pellets as a method to limit life span. The first two elements have been completed and the feasibility of injectable pellets (containing rotenone, a common fish toxicant) will be evaluated during FY01. A private company, CDS, Incorporated will develop an injectable delivery system for rotenone. Feasibility studies in small impoundments will be conducted in cooperation with Mississippi State University. Additional toxicants, efficacy of the delivery system, and locations for implantation will be evaluated in pond trials. Other uses for this new technology, including fish culture and recreational fisheries will be explored.

Impacts of *Hydrellia pakistanae* on the Growth and Photosynthetic Potential of *Hydrilla verticillata* (WU 33028, 33117, 33305)

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The impacts of varying levels of *Hydrellia pakistanae* on *Hydrilla verticillata* short-term growth and photosynthetic potential were investigated in a controlled tank study at the Lewisville Aquatic Ecosystem Research Facility, Lewisville, TX. Small cylindrical tanks (45 cm diameter, 70 cm tall) were filled with pots of pre-established *H. verticillata* and then inoculated with *H. pakistanae* larvae at one of three densities: 1, 125, and 250 larvae per tank. The tanks were covered with screens and food was provided daily for adult flies. At the end of the 10-week experimental period, tanks averaged between 0 and 4,500 larvae kg^{-1} *H. verticillata* canopy tissue. There was a linear relationship between total tank biomass of *H. verticillata* and average fly larval density per tank at harvest. The most heavily infested tanks had 60-80% of canopy leaves damaged and showed a 30% decline in *H. verticillata* biomass relative to control tanks in this short-term experiment. Individual canopy stems of *H. verticillata* showed varying levels of *H. pakistanae* larvae, ranging from 0 to 8000 immatures kg^{-1}. The percent leaf damage per stem was strongly linearly correlated to number of *H. pakistanae* larvae. Photosynthetic potential of canopy stems was strongly reduced in stems exhibiting heavy larval damage. Stems exhibiting 70% leaf damage showed strongly reduced rates of light-saturated photosynthesis (Pmax) and were estimated to be unable to meet daily respiratory demands of the stem tissues.

Hydrellia pakistanae and *H. balciunasi* - Insect Biological Control Agents of Hydrilla: Boom or Bust???? (WU 33028, 33117, 33305)

Michael J. Grodowitz
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Of the four insect species released for hydrilla biocontrol only the two leafmining flies have established and exhibited large range extensions since their first release in 1987. While monitoring has been minimal across the country, fly populations have typically remained below levels thought to be damaging. In fact, most operational personnel and many researchers have dismissed the flies as being non-effective. However, recently, modest to large increases in fly populations followed by hydrilla declines have occurred at several Texas, Georgia, and Florida sites including Lake Seminole, Coleto Creek Reservoir, and Sheldon Reservoir. Impact to hydrilla propagules has also been observed where lower numbers of tubers (~40%) were observed at sites on Lake Seminole impacted by fly feeding. In addition, long-term experimentation has indicated that even modest levels of fly damage can significantly reduce hydrilla biomass (~50%) and tuber numbers (~25%) apparently by reducing photosynthesis which leads to decreases in plant vigor and production. While more detailed field and

laboratory evaluations are needed, these agents apparently have the potential to suppress hydrilla populations based on both field and laboratory/greenhouse experimentation. However, a complex of factors can influence their effectiveness including plant nutrition and pupal parasitism. Further applied and foundational research is needed to bolster the hydrilla biocontrol program including overseas surveys to identify new agents and implementation of release programs. Based on field surveys, the release of flies into an area increases the likelihood of fly impact since actual release sites have 7-fold higher fly numbers and associated damage than non-release sites.

Impact of *Euhrychiopsis lecontei* on Eurasian Watermilfoil (WU 33189)

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Studies were designed to examine the impact of the weevil *Euhrychiopsis lecontei* on Eurasian watermilfoil and then compare the impact of three geographically different weevil populations. The first test exposed weevils to Eurasian watermilfoil grown in columns under controlled laboratory conditions. In the second test 20 columns of Eurasian watermilfoil were allowed to grow for 4 weeks. Four columns were randomly selected at the beginning of week 5 as a pre-treatment control and evaluated. The remaining sixteen columns were divided into groups of four columns each. One group was the post-untreated control and the remaining three groups received weevils for each geographic population (Vermont, Minnesota and a private company). After four more weeks all treatments were evaluated for plant height, above ground biomass, below ground biomass, and a proximate analysis of the plants.

Plant length was the only variable that showed a significant difference in the first study with treated plants being on average 30% shorter than the controls. Evaluations of chemical composition of the plants were not conducted in the first test. In the second test significant differences were again noted in plant length with treatments showing a 30-40% reduction when compared to the controls. In the second test total plant nitrogen data indicated a significant difference between the controls and the plants fed on by the weevils. The controls averaged 35 mg/g total nitrogen while, the plants receiving weevil feeding averaged 25-28 mg/g. Results indicated that all weevils populations tested significantly impacted the laboratory raised Eurasian watermilfoil.

Water Quality Impacts Following Hydrilla Control Using Triploid Grass Carp in the Santee Cooper Lakes, South Carolina

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The Santee Cooper Lakes (Lake Marion and Lake Moultrie) in South Carolina are one of the largest lake systems in the southeast covering over 170,000 acres. Originally built in 1938 for hydroelectric power production and commercial navigation, they now serve multiple water use needs and are an important economic and environmental resource in the region. Hydrilla infestations in the 1980's covered up to 48,000 acres, threatened about half the surface area, and impaired electric power production and public access and use. An integrated management strategy using triploid grass carp and aquatic herbicides was implemented in 1989 with significant reductions in hydrilla occurring in 1992 in Lake Marion and 1996 in Lake Moultrie. As part of an ongoing monitoring effort, the Charleston District U.S. Army Corps of Engineers commissioned a study to evaluate the potential impacts of hydrilla control on water quality, as well as to assess the possible impact of water quality on the control and regrowth of hydrilla in the two lakes. Water quality data including nutrients, pH, turbidity, dissolved oxygen, and chlorophyll-a were analyzed for nine stations in both lakes. Trend analysis will be presented on these constituents for the periods before and after hydrilla control.

Partnering to Develop an Endemic Fungal Pathogen as a Bioherbicide for Management of *Hydrilla verticillata* (WU 32863)

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The endemic fungal pathogen *Mycoleptodiscus terrestris* is undergoing assessment for potential development as a bioherbicide for management of *Hydrilla verticillata.* The process is a combined effort between the U.S. Army Engineer Research and Development Center (ERDC), the National Center for Agricultural Utilization Research (NCAUR), and SePro Inc. Critical to the success of the project from a research standpoint will be the development of fermentation and formulation methods. Between June and October 2000, a cooperative research effort between the ERDC and NCAUR focused on the feasibility of mass-producing *M. terrestris* in liquid culture. Important in the strategy was to determine the nutritional requirements of the organism. Benchmarks for success were based on whether the fungus could be produced at relatively low cost in a medium that yielded high numbers of viable propagules that were amenable to drying. A series of experiments examined the effects of carbon and nitrogen sources on fungal growth, propagule formation and type, viability, and biocontrol efficacy. The initial results indicate that liquid culture methods can be developed for *M. terrestris* that yield a dried product that is both viable and efficacious. Future development efforts will utilize the expertise of each of the cooperators. NCAUR will focus on optimizing fermentation and formulation methods, ERDC on laboratory and field bioassays, and SePro on product patent and registration issues.

NOTES

ALTERNATE SUBMITTED PAPERS

The Need for Retractable Fencing as a Goose Deterrent

Dick Steensland
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Because of the increasing numbers of geese in all flyways, goose problems have magnfied. Unfortunately, there haven't been many new methods to deal with these problems. Resident geese have added to the problem because of their ability to adapt to urban environments. This increased coexistence with man has led to numerous problems. Increased nutrient input to recreational lakes and potential health hazards are some of the adverse impacts. Numerous methods have been used to reduce goose impacts and problems. There are pros and cons to many of these methods. A recent development is retractable fencing. Development of retractable fencing for geese started in 1999. The development included testing at pond and lake sites to determine how best to apply this method of control for geese. Installations of retractable fencing throughout theU.S. have provided important installation information and site-specific criteria to evaluate before employing this technique for goose control.

An Update on the Status of *Salvinia molesta* in North Carolina

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Giant salvinia (*Salvinia molesta*) was first discovered in North Carolina at an exhibit at the NC State Fair in October 1998. It had been found in nurseries, dealerships, personal water gardens, and a few isolated in-ground ponds in about 20 NC counties since its initial discovery, but was not found naturalized until late summer of 2000. Following a tip received in August from a commercial aquatic applicator, this weed was found in several ponds on a golf course in Brunswick Co. In September, the weed was reported in two ponds on another golf course at Wilmington. The identity of the weed at these sites was confirmed by personnel from the North Carolina Department of Agriculture and Consumer Services (NCDA&CS) and North Carolina State University (NCSU). During a pond management workshop in September in Kinston, NC, a property owner brought in a live sample of giant salvinia from a pond in Jacksonville, and another aquatic applicator reported a large infestation in a swamp pond within a subdivision adjacent to the Northeast Cape Fear River east of Burgaw, NC. Plants from the Jacksonville site were washed out of the pond and into an adjacent swamp during flooding in September. The site currently of greatest concern is the swamp pond near Burgaw. Property owners here indicated that this weed has been present for at least three or four years. Giant salvinia is present in the open water that encircles a swampy wetland. Plants were visible well back into the trees in the wetland and in a small drainage canal paralleling the road just east of this site. Some waterhyacinths also were seen in the canal. The pond, including the encircled wetland, occupies 15 acres, and has been flooded several times. In fall 1999, ten to twelve feet of water covered the road next to the pond. Dead salvinia was found hanging in trees ten to twelve feet above the ground, where they were stranded during the flooding following Hurricane Floyd in 1999. This site is only 100 ft. from the Northeast Cape Fear River, and stranded plants were found in trees within 30 ft. of the river. Spraying at this location and the golf course sites has not eliminated the Salvinia. Field observations during spring of 2001 indicate that the weed once again has overwintered successfully. Field surveys and further treatments are planned for the immediate future. This paper will provide an update on the distribution of giant salvinia and the success of its control in North Carolina through early July 2001.

HELP: Habitat Enhancement Lake Project

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Many Texas reservoirs suffer from poor water quality, eroding shorelines, and a lack of quality fish habitat and are susceptible to invasions by weedy exotic plant species. A well-developed native plant community would be very beneficial in these man-made systems. Aquatic plants have a significant role in natural lake ecosystems and provide valuable food and habitat for fish and wildlife. These plants are also important in reducing shoreline erosion and sediment resuspension while improving water clarity and quality. Unfortunately, most Texas reservoirs are located far from natural sources of aquatic plant seeds and will require intervention in order to establish native aquatic plant communities. Therefore, HELP: Habitat Enhancement Lake Project was designed as a "hands-on" education and restoration program to help introduce native Texas aquatic plants to our local reservoirs and wetland areas. In addition to educating our youth about aquatic ecology and the dangers of invasive species the project will provide tangible benefits in water quality and habitat improvement and will hopefully slow the spread of harmful exotic plants such as Hydrilla. The pilot project, developed under the technical

guidance of scientists at the Lewisville Aquatic Ecosystem Research Facility in Lewisville, Texas, enlists participation of local teachers (K – 12) in the raising of aquatic plants in the classroom for eventual planting in local reservoirs and wetlands.

The first year of this pilot project included two high schools, one middle school and one elementary school within the Lewisville Independent School District (LISD) in Texas. Large 150-gallon growth tubs were used to raise Illinois pondweed (*Potamogeton illinoensis*) while kiddy pools were used to raise emergent plants such as bulltongue (*Sagittaria)*, spikerush (*Eleocharis)*, and bulrush (*Scirpus)*. At the beginning of May, teachers, students and volunteers met at a newly constructed wetland area adjacent to Lake Lewisville to plant the aquatic plants they had grown. This project allowed students to participate in the restoration of a wetland area, meet state standards (Texas Essential Knowledge and Skills- TEKS) for reading, math, critical thinking, laboratory activities and community service.

POSTERS

Preliminary Investigations of Low Temperature Limits of *Salvinia molesta* in the United States

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Salvinia molesta (Mitchell), or giant salvinia, is a floating aquatic fern, native to southeastern Brazil that currently occurs in all subtropical and tropical regions worldwide. Giant salvinia was discovered in a Houston, TX, schoolyard in 1997, and by 1998 it had been documented in Toledo Bend Reservoir. By year 2000, giant salvinia had been documented in 4 reservoirs, 5 riverine systems and 20 ponds throughout eastern and southern Texas. Its occurrence had also been documented in 9 other states. Its most northern documented location in the United States to date is at the Lewisville Aquatic Ecosystem Research Facility (LAERF) in Lewisville, TX (latitude 33°04'45"N, longitude 96° 57'30"W).

At the LAERF, three outdoor research ponds containing giant salvinia have been exposed to two Texas winters (1999-2000, 2000-2001). During these winter periods, preliminary investigations were undertaken to determine low temperature effects on giant salvinia survival. Giant salvinia was found to survive 17 freezing events during the winter of 1999-2000, although a significant reduction in percent survival occurred after a major freezing event that persisted over a four day time period. In a related acute freezing assay conducted with winter acclimated plants, giant salvinia exhibited 100 % survival from 48 hour exposures to 0 C (32 F) and -4 C (25 F). Plants survived 24-hour exposures to -16 C (3 F) with minimal mortality; however, heavy mortality resulted from 48-hour exposures to this temperature.

Investigation of Aquatic Plant Fragment Dispersal in the San Marcos River Below Spring Lake, Texas (WU 33188)

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The San Marcos River, a spring-fed system originating from the Edwards Aquifer, supports a diverse community of native and nonnative aquatic plants, including *Hydrilla verticillata*. Quarterly samples (May, June, September, and December 2000) of drifting fragments were collected to evaluate effects of distance from suspected fragment sources and temporal factors (i.e., season, time of day, and day of week) on *in situ* fragment loadings (i.e., fragment numbers and biomass), and to evaluate viability of collected hydrilla fragments.

Fragment collections were made from five sites (1-5). Suspected sources of fragment generation were (a) Spring Lake, where seasonal mechanical harvester operations were conducted, and (b) Sewell Park, a high-use recreational area. Sites 1 and 2 were located 35-m and 529-m, respectively, below Spring Lake dam, while Sites 3, 4, and 5 were located further downstream, at distances of 25-m, 450-m, and 1000-m below Sewell Park. Drifting fragments of 16 aquatic plant species were collected. Plant species with most frequent collections were the exotic *H. verticillata* and *Hygrophila polysperma*, followed by natives *Ceratophyllum demersum* and *Potamogeton illinoensis*. Numbers of drifting fragments showed significant declines with increases in distance from high use areas. Similar numbers of fragments were collected in March and June at the two sites (Sites 1 and 3) located immediately downstream of the suspected fragment sources. At Site 1, reductions in fragment numbers during September and December coincided with seasonal cessation of submersed aquatic plant harvesting activities in Spring Lake. At Site 3, highest fragment numbers were collected in September, coinciding with peak plant abundance and high recreational water activities. At Site 3, greater fragment numbers were also collected in the afternoon and on weekends, again coinciding with assumed times of increased water activities. Unlike fragment numbers, there were no apparent relationships for fragment biomass levels. Hydrilla fragment viability was assessed for both March and June collections by determining the percent of planted fragments that generated firmly established roots 30 days after being planted and placed under standard greenhouse culture conditions. Tests were conducted for both "fresh" fragments and

fragments that had been "aged" for 30 days prior to planting. Established roots were generated by 83% of "fresh" fragments planted in March and 70% of those planted in June. For the "aged" treatment, established roots were generated by 88% of March fragments and 70% of June fragments.

Concepts for Modeling Competition Between Submersed Macrophyte Species (WU 33308)

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To predict changes in vegetation as a result of changes in resource availability in shallow freshwater bodies a simulation model is being developed that focuses on the ability of two competing submersed plant groups, respectively canopyforming and non-canopy-forming, to maintain their biomass at different environmental conditions. Currently considered are Sago pondweed for canopy-forming plants, and American wildcelery for non-canopy-forming plants. The two plant groups compete for light, inorganic carbon and nutrients (nitrogen and phosphorus). This model will be based partly on insights gained from previously developed growth models for macrophyte species with light as limiting factor. The literature on clonal behavior in submersed plants has been explored, but inclusion of clonal behavior into the model was rejected, because evidence of direct profits for these plants is lacking. Initial simulation results will be verified by comparison with new experimental data on the growth responses of both plant species to different interstitial N- and P-concentrations.

Impacts of Sediment Dewatering and Reflooding on Emergence of Aquatic Plant Propagules (WU 33029, 33309)

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Soft, flocculent sediments, commonly found in shallow eutrophic systems, are major contributors to turbidity, nutrient release to the water column, and sediment resuspension. Lake-level drawdowns potentially offer an effective means of consolidating sediments and improving water clarity upon refilling. One desired outcome of drawdown procedures and the consolidation of sediments is the stimulation of native aquatic plant growth after reinundation to help reduce concentrations of suspended materials. However, current knowledge of the impacts of drawdown needs much improvement, particularly regarding effects on the viability of buried aquatic plant propagules (i.e., seeds, root crowns, tubers, and turions). Recently, studies were begun in a controlled environment facility to assess changes in species emergence from propagules in dewatered and reflooded sediments. The sediments, collected from sites in the Upper Mississippi River, are being dried to achieve different moisture contents prior to being reinundated. The young plants that emerge after the sediment has been reflooded will be allowed to grow to maturity for positive species identification. The status of this research will be reported, with emphasis on survival of different species and implications for management programs.

Studies of Seed Germination in *Trapa natans* L. (Water Chestnut) with Emphasis on Impacts of Cold Stratification (WU 33029)

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Investigations were conducted in 1999-2000 to assess the density of viable seeds of water chestnut (*Trapa natans* L.) in Lake Champlain, Vermont-New York. Six study sites were selected in the southern end of the lake in areas heavily dominated by water chestnut populations. Seed counts from sediment cores collected in June (1999) revealed high densities of seeds, ranging from 382 to 970 m^{-2} at the study sites. However, the vast majority of the seeds (78 to 92 percent) proved to lack endosperm, apparently due to germination that had occurred earlier. Among seeds with intact endosperm, 72 percent germinated, but did so only after a period (12 wks) of cold stratification. Low temperature effects on viability were then studied further, using mature seeds of water chestnut that had been cultured in a greenhouse. The seeds were divided into seven groups ($n = 30$) and were tested for viability in a growth chamber after 0, 1, 3, 6, 9, 12, and 18 wks in a cold room (at 6 C). Percentage germination was greatest (80 percent) in seeds chilled 9 to 12 wks, whereas seeds that had not been chilled failed to germinate. The number of days for germination declined from 48 to 4 days between 1-wk and 18-wk cold-treated

seeds. Results of these studies indicate the length of cold exposure to be important in affecting the speed and percentage of water chestnut seed germination. Also, the number of seed coats of this species present after germination should be assessed in field studies needing to exclude nonviable seeds from seed density estimates.

Direct and Indirect Impacts of Submersed Aquatic Vegetation on the Nutrient Budget of an Urban Oxbow Lake (WU 33201)

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Submersed aquatic macrophytes can play an important role in the phosphorus (P) budget of aquatic systems; thus, their impacts need to be considered in lake management and rehabilitation plans. In particular, macrophytes can directly recycle P from the sediment via root uptake, incorporation into tissue, and subsequent senescence. They can also indirectly recycle P from the sediment via increasing pH in the water column through photosynthetic activities. P release from sediments can be enhanced at high pH as a result of ligand exchange on iron-oxides contained in the sediment. These processes can lead to P enrichment of aquatic systems and eutrophication. The objectives of this study were to evaluate direct and indirect impacts of a near monotypic stand of *Potamogeton crispus* L. on the P economy of Half Moon Lake. Using mesh bag techniques and laboratory leaching studies, we found that *P. crispus* decomposition accounted for ~26% of the measured internal P load during the summer. Even at a relatively low biomass level of 25 g m^{-2} near the time of plant decomposition, the internal P loading rate via decomposition was high at 1.2 mg m^{-2} d^{-1}. *P. crispus* also had an indirect impact on P recycling by stimulating enhanced P release from sediment as a result of pH and ligand exchange, induced by photosynthetic activities. P release from sediments accounted for over 50% of the measured internal load to this lake.

Changes in Aquatic Sediment Characteristics Due to Desiccation: Implications of Submersed Aquatic Macrophyte Growth and Water Quality Conditions in Shallow Lakes (WU 33309)

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The positive roles played by submersed aquatic macrophytes in reducing sediment resuspension in shallow lakes and reservoirs may often be disturbed by high external nutrient loadings and turbidity, unexpected lake level fluctuations, explosions of benthic fish communities, and/or other ecosystem-level stresses such as strong storms or high winds, resulting in macrophyte community instability and a changeover to a more turbid, algal dominated state with loss of macrophyte dominance. One of the goals of shallow lake rehabilitation, therefore, is the re-establishment and maintenance of stable submersed macrophyte communities for purposes of reducing sediment resuspension, sediment export, and improving water quality. One technique available for inducing macrophyte growth in shallow, algal-dominated systems is a lake drawdown to promote sediment consolidation, reduce resuspension potential, and promote greater light penetration for macrophyte growth. However, sediment desiccation may result in some undesirable impacts such as enhanced rates of nutrient release from sediments after refill. N and P release to the water column and stimulation of excessive algal growth could result in competition for available light. We examined changes in sediment physical/chemical characteristics due to desiccation in experimental laboratory systems for sediments collected in Pool 8 of the Mississippi River. Moisture content declined, while density increased, indicating consolidation of sediment. Sediment N and P release increased dramatically, coincident with increased concentrations of exchangeable NH_4-N and loosely-bound P. These positive (i.e., sediment consolidation) and negative (i.e., sediment nutrient release) impacts of drawdown on sediment dynamics need to be considered in shallow lake rehabilitation programs.

Suspended Sediment Dynamics and Light Attenuation Characteristics in Peoria Lake: Can Submersed Macrophytes Improve Water Quality in This Shallow System? (WU 33128)

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Large fetches along prevailing wind rose, coupled with shallow morphometry and sediment particles composed of >90% silt and clay results in frequent periods of sediment resuspension and high light attenuation in Peoria Lake, a very large, shallow impoundment of the Illinois River. Using a resuspension model, we were able to reasonably predict most resuspension events that occurred at a resuspension station in September, 2000. Model explorations suggested that establishment of submersed aquatic macrophytes could substantially reduce sediment resuspension in Peoria Lake. However, K_d was very high, while Secchi transparency low, at in-lake stations and the silt fraction (i.e., < 62.5 μm and > 1.95 μm) strongly influenced K_d. Thus, in order to establish a persistent macrophyte population in the lake to control resuspension, the underwater light regime will have to be initially improved quite dramatically.

Preliminary Evaluation of the Ecological Effects of Giant Salvinia (WU 33186)

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A preliminary investigation of the ecological effects of Giant Salvinia (*Salvinia molesta*) began in the fall of 1999 and continues to the present. The objective of this study is to document the ecological effects of giant salvinia infestations on aquatic ecosystems. Replicate ponds have been planted with giant salvinia or native aquatic plant species. As the vegetation develops, resultant changes in the environmental conditions and ecological characteristics of the ponds are being monitored. Water quality assessment includes semi-continuous recording of temperature, dissolved oxygen, and pH. Nutrient concentrations, alkalinity, specific metals, and chlorophyll concentrations are also being measured. Light penetration is being measured throughout the water column and the concentrations of nutrients in the sediment and sediment interstitial water are being assessed on a regular basis.

Results to date indicate that giant salvinia rapidly grows to cover the water surface during the summer and fall of the year. This canopy of salvinia blocks light penetration, impedes wind-generated mixing of the water column, and greatly suppresses the entry of atmospheric oxygen, resulting in anaerobic conditions. Giant salvinia ponds are characterized by reduced levels of oxygen and pH and a much simpler vegetative community in comparison with ponds planted with native species. As a result of its excessive growth rate and the resultant environmental changes associated with its growth, giant salvinia has the potential to destroy valuable fish and wildlife habitat.

U.S. Army Corps of Engineers Aquatic Plant Control Research Program (WU 31577)

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The U.S. Army Corps of Engineers (CE) Aquatic Plant Control Research Program (APCRP) is the Nation's only federally authorized research program directed to develop technology for the management of nonindigenous aquatic plant species. The APCRP is designed to provide effective, economical, and environmentally compatible methods for assessing and managing problem aquatic plants that interfere with the valued uses of the waterways of the United States. Research efforts are currently focused on the development of advanced management strategies and applications for the submersed aquatic plants, hydrilla (*Hydrilla verticillata* (L.f.) Royle) and Eurasian watermilfoil (*Myriophyllum spicatum* L.). The APCRP is committed to the development, transfer, and implementationof aquatic plant management technologies, and will continue to lead the Nation in the future.

Mass-Rearing *Hydrellia pakistanae* and *H. balciunasi*, Biological Control Agents of *Hydrilla verticillata*, Using Fish Hatchery Ponds (WU 33028)

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The ability to produce large numbers of high-quality insects for use in biocontrol programs is an essential and often critical component for success. However, mass-rearing costs are often labor intensive and prohibitively expensive. For example, past greenhouse rearing of the introduced *Hydrellia* flies produced high-quality individuals based on longevity, egg production, survival, and establishment success but at a cost of over $0.50 per fly. New mass-rearing techniques are needed that allow the production of large numbers of flies but at reduced costs and labor. Toward this goal, two rearing techniques were evaluated at the Lewisville Aquatic Ecology Research Facility (LAERF) fish hatchery ponds during 2000. For the first technique, adult *Hydrellia* spp. were hand collected from ponds at LAERF using a portable vacuum system and subsequently released into large oviposition chambers. After the larvae developed into second and third instars, the hydrilla sprigs containing the immatures were shipped for field release or used to replenish pond populations for future collections. The second technique relied on the harvesting of large amounts of hydrilla from ponds with high numbers of immatures. The harvested plant material was then shipped to field sites for release. The second technique was by far the most productive and less labor intensive producing over 400,000 immatures compared to only 1200 for the first procedure. Costs were substantially reduced as compared to past greenhouse rearing techniques in that costs per fly were reduced 25 fold to only 2 cents per fly.

Sensitive Area Survey – A Management Tool for Critical Habitat Protection

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A sensitive area survey is a tool used by natural resource managers to protect, manage, or restore the critical habitat of a lake. These surveys are an integrated team approach to resource management because they utilize the expertise of many DNR resource managers. As a team, DNR fishery biologists, water resource specialists, water regulations personnel, aquatic plant specialists, wildlife biologists, etc. are able to identify the existing critical habitat areas around a waterbody which are vital to ensuring the future health and balance of the lake's ecosystem.

Sensitive areas typically include locales around a lake that are rich in aquatic macrophyte growth, areas that contain submersed woody cover or gravel/rubble bottom substrate, and locales around the shoreline that are rich with riparian vegetation. Each of these types of areas contribute to the health of the lake's ecosystem by offering critical or unique fish and wildlife habitat, lake water quality protection, or erosion control benefits.

Sensitive area surveys provide an information tool to help DNR personnel generate management recommendations. This type of survey can also provide information needed by local lake organizations, shoreline property owners, county zoning officials, and other interested persons to initiate local government actions aimed at critical habitat protection.

A survey on the Pike Chain of Lakes was conducted in August of 2000 as part of a pilot study to create standardized guidelines for sensitive area surveys. The resulting guidelines for conducting and implementing sensitive area surveys will allow for consistency in future surveys of this kind.

Plant Quantification for Minnesota's Statewide Lake Assessment

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The Minnesota Department of Natural Resources (MnDNR) Fisheries, Division is responsible for fisheries' habitat management on thousands of Minnesota lakes. Fisheries biologists collect information on macrophyte communities in about 150 different lakes each year. Because of high number of lakes surveyed, a rapid, mostly qualitative survey method is currently used.

Quantitative data on plant species distribution, abundance and composition are needed to adequately describe, monitor and assess change in macrophyte communities. This study compares the current qualitative transect method used by MnDNR

Fisheries with a quantitative point survey method. This point survey provides a relatively rapid method for nonbotanists to collect non-biased, quantitative plant data from a boat surface.

Results indicate that the point survey method provides more accurate estimates of species frequency than did the transect survey. Data from the point survey also provide estimates of percent of littoral zone with vegetation, assessment of species occurrence and abundance at different water depths, and the ability to map various plant community types and depth contours within a lake.

This point survey method was evaluated on four lakes with different aquatic macrophyte community types: 1) a shallow, algal dominated lake with sparse rooted vegetation, 2) a wild rice dominated lake, 3) a lake with an abundant and species rich macrophyte community, 4) a lakewith an endangered aquatic plant species. Recommendations are given for sample placement, minimum sample number and sample plot size. The time required to complete the survey in different lake types is also discussed.

Current Status of Introduced *Hydrellia* spp. at Sixteen Southeast Field Sites Surveyed in 2000 (WU 33028)

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Sixteen field sites were sampled in the southeast for the presence *H. pakistanae* and *H. balciunasi*, insect biocontrol agents of *Hydrilla verticillata*. Field sites surveyed during 2000 included nine in Louisiana, six in Texas, and Lake Seminole. Of the sixteen sites, four had previous releases of *Hydrellia* spp. (one in Louisiana, two in Texas, and Lake Seminole), while the remaining were non-release sites. *Hydrellia* spp. were found at all of the release sites and at seven of the non-release sites.

The three Lake Seminole areas (Three River, New Flats, and Decatur) had both immatures and damaged leaves. Decatur had the highest with 4.1% damaged leaves and 290.66 immatures/kg of plant material. Three areas on Coleto Creek (Eagle Nest, Cove, and Area 2) had damaged leaves of 11.00%, 3.73%, and 3.42%, respectively. In Texas, immatures/kg were highest at Lake Raven (554.65); followed by Coleto Creek, Cove (266.37); and Coleto Creek, Area 2 (255.92). Non-release sites in Louisiana with leaf damage included Lake Iatt (0.47%) and Lake Kincaid (0.32%), which also had 29.86 and 26.77 immatures/kg respectively. While no damage or larvae occurred at two sites in Louisiana and two in Texas, the collection of adults indicated establishment.

The presence pf *Hydrellia* spp. at 58% of the non-release sites indicates that the insects are becoming well distributed throughout the southeast. Signs of hydrilla decline were observed at Coleto Creek, Texas. Lake Seminole had exhibited signs of decline in 1999, but these were not as apparent in 2000.

Endophytic Fungi Associated with *Myriophyllum spicatum* (WU 33306)

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Over the past ten years, Eurasian watermilfoil populations have been routinely sampled for the purpose of isolating potential fungal pathogens for biocontrol purposes. For each sample, the isolates were identified when possible, preserved in cryostorage, and a species list was compiled indicating frequency of occurrence. Examination of the compilations and collection data from the ten-year period showed consistent and repetitive isolation of some species from both asymptomatic and stressed milfoil populations suggesting the fungi were living as endophytes within the host. The most intensively studied areas were on the Tennessee and Cumberland River systems. The results of one collecting trip revealed that *Mycoleptodiscus terrestris* accounted for 81 percent of 482 total isolates obtained from 52 milfoil-inhabited sites, followed by *Pythium* sp. and *Acremonium* sp. at eight percent and three percent respectively. *M. terrestris* has also been the dominant species collected on several occasions from the same sites in Vermont, Minnesota, Illinois, Tennessee, Kentucky, and Alabama. The high frequency of isolation of *M. terrestris* from milfoil populations apparently under stress, stress or undergoing senescence places it in a category of endophytes that are often referred to as latent pathogens. Current research efforts are focusing on what environmental or nutritional conditions trigger *M. terrestris* to switch from a benign endophyte to a pathogenic organism.

Assessing Wild Rice (Zizania palustris) Productivity and the Factors Responsible for Decreased Yields on Rice Lake, Rice Lake National Wildlife Refuge, McGregor, MN

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Wild rice (*Z. palustris*) is an annual aquatic grass, adapted to northern latitudes, that thrives where perennials are not abundant. It is vulnerable to nutrient deficiency during early growth stages and after panicle formation, when its nitrogen demand is high. On Rice Lake, control structures have been used to keep the lake level constant during summer months, which likely has had an effect on lake vegetation communities, genetic variability of wild rice, and water quality. Pickerelweed (*Pontederia cordata*), an aquatic perennial that slowly proliferates by rhizomes, is now abundant in formerly thick wild rice beds. We are interested in whether wild rice yields are actually decreasing over time, and the primary causes of decreases. To address these concerns, historical data is being catalogued and reviewed for evidence of decreased wild rice productivity. This information will be compared to data collected on sediment properties and plant mineral nutrition along lake transects, to identify possible stressors to wild rice. A GIS program is also being designed to enable refuge staff to properly monitor changes in the plant communities of the lake. The data suggest that nutrient competition is not the main mode of pickerelweed competition with wild rice. Available phosphorus in sediments decreases with distance from the shore and phosphorus deficiency may have a significant role in the distribution of highly productive wild rice beds. Poor wild rice growth in one season may result in a larger sediment store of readily available nitrogen for the following season, and may have a role in the annual variability of wild rice production.

Interactive Effects of Water Depth and Propagule Type on Short-Term Establishment of American Waterwillow, *Justicia americana* (WU 33084)

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In order to restore native vegetation in aquatic ecosystems that have been degraded by longterm infestations of exotic species, or to establish desirable native plants as a deterrent to weed invasion of unvegetated systems, we need to understand and overcome obstacles to natural establishment. In many cases, propagules of desired species are lacking, so it is obvious that we must supply them. It is equally obvious that the environmental conditions that these propagules will encounter are less than optimal. Excessive grazing and disturbance by herbivores and omnivores have been shown to be major deterrents to plant establishment. High levels of turbidity, particularly when combined with fluctuating water levels have also been shown to be problematical.

In this experimental pond study we evaluated short-term establishment of rooted plants and unrooted cuttings of American waterwillow, an emergent aquatic plant, planted at water depths up to 1.5m. American waterwillowwas chosen for study because this species is easily propagated and does not seem to be favored by grazers. As a result, American waterwillow is often planted in restoration/habitat enhancement projects.

Survival and growth occurred at all depths for both rooted plants and cuttings. Biomass of cuttings was greatly reduced relative to that of plants under flooded conditions but was similar under emergent conditions. Biomass of plants was reduced at water depths of 75 cm or greater. Unrooted cuttings could serve as economical and readily available propagules for use in moist soils in environments with relatively stable water levels; however, rooted plants are more versatile in terms of planting depths and are more likely to recover following grazing or prolonged periods of inundation

Integrating Fluridone with a Fungal Pathogen for Control of Eurasian Watermilfoil (WU 32953)

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Growth chamber studies were conducted to evaluate the efficacy of the herbicide fluridone and the endemic fungal pathogen *Mycoleptodiscus terrestris* (Gerd.) Ostazeski (Mt), applied alone and in combination with one another against the nuisance aquatic plant, *Myriophyllum spicatum* L. (Eurasian watermilfoil). Treatments included 2, 5, and 12 $\mu g\ L^{-1}$ fluridone, 50, 100, 200, and 400 colony forming units (cfu) ml^{-1} Mt, combined treatments of fluridone (all rates) with either 50, 100, or 200 cfu ml^{-1} Mt, and untreated controls. Compared with untreated plants, all integrated treatments of fluridone and Mt significantly reduced Eurasian watermilfoil growth 84 days after treatment (DAT). Rates as low as 5$\mu g\ L^{-1}$ fluridone applied

simultaneously with 200 cfu ml^{-1} Mt reduced milfoil biomass by 93%, whereas either product applied alone was ineffective in reducing plant growth. The data showed that integrating Mt with fluridone improved plant control while minimizing chemical use rates.

Preliminary Ecosystem Analysis of Experimental Ponds Vegetated with Native or Exotic Plant Species (WU 33186)

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Replicate experimental ponds at the Lewisville Aquatic Ecosystem Research Facility, located in Lewisville, Texas, were planted with either a diverse mixture of native plant species or with a non-indigenous, invasive species. The objective of the study is to monitor the development of the vegetation component of these experimental ecosystems and to assess its influence on key ecosystem attributes. Water, plants, sediments, and biota are being sampled in this ongoing investigation. Of primary interest are the levels of dissolved oxygen, pH, and nutrients in the water column and the effects of vegetation and resultant water chemistry on the development of the fish community (largemouth bass and bluegill).

Ponds planted with the non-indigenous species, Eurasian watermilfoil (*Myriophyllum spicatum*) or hydrilla (*Hydrilla verticillata*), initially supported a mixture of native species including chara, southern naiad, American pondweed, and a few emergent species such as bull tongue (*Sagittaria graminea*) and flatstem spikerush (*Eleocharis macrostachya*). Over time the ponds planted with hydrilla or Eurasian watermilfoil exhibited an increasing presence of these problematic species, while the ponds planted with natives have increased in species richness and diversity. Ponds dominated by the non-indigenous, canopy-forming species exhibited low levels of dissolved oxygen, high surface water pH and low levels of light penetration. Populations of both largemouth bass and bluegill were affected by vegetation type and abundance. Aquatic plant communities likely affected fish populations directly, by their effects on fish growth and development (through prey availability), and indirectly, by affecting oxygen levels which in turn may have contributed to mortality.

Technology Transfer for Invasive Species via Computer-Based Information Systems (WU 31557)

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A large number of invasive species (noxious and nuisance plants, zebra mussel, etc.) cause serious problems in many areas of the United States. Since there are a tremendous number of management options available for the control of these species, one must have the ability to readily and efficiently obtain pertinent information on the various control methods. This information is essential to operational personnel in determining the most effective strategy for controlling a certain species in a given environment. For this purpose, several computer-based information/expert systems have been developed that provide rapid and easy access to up-to-date information on various management and control methods available for particular species. The systems are PC-based and operate under Windows® ensuring a high degree of portability for a wide variety of different computer configurations. The systems contain large amounts of textual information as well as numerous photographic quality diagrams and images. Information covered is system dependent but all operate using sophisticated programming algorithms that allow for easy identification of invasive species or available management options. The systems include the Noxious and Nuisance Plant Management Information System (PMIS), the Aquatic Plant Information System (APIS), the Zebra Mussel Information System (ZMIS) and the Ecosystem Management and Restoration Information System (EMRIS). Of the following, the ZMIS is currently being distributed. The others are being updated and are scheduled for release in the near future.

Use of Hydroacoustic Survey Techniques to Quantify SAV Changes Following an Upstream Sonar Injection Treatment in Spring Creek, Lake Seminole, Georgia (WU 33127)

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The purpose of this poster presentation is to demonstrate the use of hydroacoustic survey techniques for evaluating changes in submersed aquatic plant abundance levels following implementation of largescale control measures. Hydroacoustic survey data used in this demonstration were acquired using the Submersed Aquatic Vegetation Early Warning System (SAVEWS) developed by the US Army Engineer Research and Development Center. The automated processing algorithm of SAVEWS provided estimates of average water depth, plant height, and midpoint geographical coordinates for discrete linear segments (~ 2 to 5 meters) of the surveyed area. The surveys were conducted in the Spring Creek arm of Lake Seminole, Georgia, during May (PRE) and September (POST) 2000, coinciding with a large-scale injection treatment of the aquatic herbicide, fluridone, applied for control of the exotic, invasive plant species, *Hydrilla verticillata* (L.f.) Royle. The intent of the injection treatment was to provide control of hydrilla throughout the 15.8-kilometer portion of Spring Creek downstream of the injection site, located just upstream of the Hiway 253 bridge.

For both survey periods (PRE and POST), SAVEWS transects were surveyed along the 15.8-kilometer length of the Spring Creek navigation channel, from the Highway 253 bridge to its intersection with the Fish Pond Drain navigation channel. Resulting data sets have been analyzed to determine how far downstream measurable changes in plant abundance (e.g., plant height and plant-height:water-depth ratios) were achieved. These change analyses indicate that significant reductions in mean plant height and in plant-height:water-depth ratios were achieved to a distance of approximately 10-kilometers below the Highway 253 bridge.

Changes in Plant Response to Aquatic Herbicides (WU 74001)

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Major efforts in the Corps of Engineers chemical control technology area of the Aquatic Plant Control Research Program (APCRP) were undertaken in the 1980's to understand herbicide concentration and exposure time (CET) relationships for improving the management of target plants in flowing water systems. In the 1990's, research emphasis shifted to the utilization of herbicide CET information to improve low-dose and species-selective control techniques. An important issue facing chemical control technologies in the next decade is the possibility of differential response or tolerance in species or populations of plants to aquatic herbicides. Data and anecdotal information indicate that discrete populations of submersed aquatic plants can alter their physiological response to some herbicides after multiple exposures to chemical treatment. The occurrence of this type of response could seriously affect the efficacy and predictability of chemical techniques for managing nuisance aquatic vegetation. Since the development of new active ingredients for aquatic plant control is unlikely in the near future, information on the causes of treatment-induced differential plant response is needed to manipulate control strategies for currently registered products. These strategies would include application rate and timing of treatment, use of herbicide combinations, rotational use of selected herbicides, and frequency of herbicide use. Similar strategies have been used to successfully counteract species tolerance and/or resistance problems in agricultural systems. A new APCRP work unit is proposed to address potential changes in plant response to aquatic herbicides.

HELP: Habitat Enhancement Lake Project

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Many Texas reservoirs suffer from poor water quality, eroding shorelines, and a lack of quality fish habitat and are susceptible to invasions by weedy exotic plant species. A well-developed native plant community would be very beneficial in these man-made systems. Aquatic plants have a significant role in natural lake ecosystems and provide valuable food and habitat for fish and wildlife. These plants are also important in reducing shoreline erosion and sediment resuspension while improving water clarity and quality. Unfortunately, most Texas reservoirs are located far from natural sources of aquatic plant seeds and will require intervention in order to establish native aquatic plant communities. Therefore, HELP: Habitat Enhancement Lake Project was designed as a "hands-on" education and restoration program to help introduce native Texas aquatic plants to our local reservoirs and wetland areas. In addition to educating our youth about aquatic ecology and the dangers of invasive species the project will provide tangible benefits in water quality and habitat improvement and will hopefully slow the spread of harmful exotic plants such as Hydrilla. The pilot project, developed under the technical

guidance of scientists at the Lewisville Aquatic Ecosystem Research Facility in Lewisville, Texas, enlists participation of local teachers (K – 12) in the raising of aquatic plants in the classroom for eventual planting in local reservoirs and wetlands.

The first year of this pilot project included two high schools, one middle school and one elementary school within the Lewisville Independent School District (LISD) in Texas. Large 150-gallon growth tubs were used to raise Illinois pondweed (*Potamogeton illinoensis*) while kiddy pools were used to raise emergent plants such as bulltongue (*Sagittaria*), spikerush (*Eleocharis*), and bulrush (*Scirpus*). At the beginning of May, teachers, students and volunteers met at a newly constructed wetland area adjacent to Lake Lewisville to plant the aquatic plants they had grown. This project allowed students to participate in the restoration of a wetland area, meet state standards (Texas Essential Knowledge and Skills- TEKS) for reading, math, critical thinking, laboratory activities and community service.

An Update on the Status of *Salvinia molesta* in North Carolina

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Giant salvinia (*Salvinia molesta*) was first discovered in North Carolina at an exhibit at the NC State Fair in October 1998. It had been found in nurseries, dealerships, personal water gardens, and a few isolated in-ground ponds in about 20 NC counties since its initial discovery, but was not found naturalized until late summer of 2000. Following a tip received in August from a commercial aquatic applicator, this weed was found in several ponds on a golf course in Brunswick Co. In September, the weed was reported in two ponds on another golf course at Wilmington. The identity of the weed at these sites was confirmed by personnel from the North Carolina Department of Agriculture and Consumer Services (NCDA&CS) and North Carolina State University (NCSU). During a pond management workshop in September in Kinston, NC, a property owner brought in a live sample of giant salvinia from a pond in Jacksonville, and another aquatic applicator reported a large infestation in a swamp pond within a subdivision adjacent to the Northeast Cape Fear River east of Burgaw, NC. Plants from the Jacksonville site were washed out of the pond and into an adjacent swamp during flooding in September. The site currently of greatest concern is the swamp pond near Burgaw. Property owners here indicated that this weed has been present for at least three or four years. Giant salvinia is present in the open water that encircles a swampy wetland. Plants were visible well back into the trees in the wetland and in a small drainage canal paralleling the road just east of this site. Some waterhyacinths also were seen in the canal. The pond, including the encircled wetland, occupies 15 acres, and has been flooded several times. In fall 1999, ten to twelve feet of water covered the road next to the pond. Dead salvinia was found hanging in trees ten to twelve feet above the ground, where they were stranded during the flooding following Hurricane Floyd in 1999. This site is only 100 ft. from the Northeast Cape Fear River, and stranded plants were found in trees within 30 ft. of the river. Spraying at this location and the golf course sites has not eliminated the Salvinia. Field observations during spring of 2001 indicate that the weed once again has overwintered successfully. Field surveys and further treatments are planned for the immediate future. This paper will provide an update on the distribution of giant salvinia and the success of its control in North Carolina through early July 2001.

Development of a New Sonar Aquatic Herbicide Pellet Formulation and Evaluation of Performance Characteristics

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For the past several years the SePRO Corporation has conducted an active research effort to characterize the release and performance of Sonar SRP (Slow Release Pellet) under various environmental conditions. Furthermore, operational use of the FasTEST has facilitated a greater understanding of Sonar SRP and the conditions which influence efficacy. As a result of the findings of the SRP research, a new Sonar pellet formulation has been registered for aquatic use. Field development trials include treatment sites with higher flow or dilution, treatments for small water bodies, canals, and plants which require higher initial threshold rates (egeria, sago pondweed, more tolerant strains of hydrilla). Laboratory and field results suggest that this formulation will provide a unique fluridone profile in the water column compared to either Sonar SRP or the liquid Sonar A.S.

Genetic Diversity Among Brazilian Elodea Accessions From Sao Paulo State – Brazil by RAPD Analysis

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No abstract provided.