ABSTRACTS

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ANNUAL MEETING

THE AQUATIC PLANT MANAGEMENT SOCIETY, INC.

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Exotic Plants: What's the Problem?

R. Michael Smart, USAEWES Lewisville Aquatic Ecosystem Research Facility, Lewisville, TX

It is increasingly difficult to justify aquatic plant control because the problems are less obvious, costs are increasing, and fear of herbicides has reached near-hysterical levels. At a time when we are nearing our goal of truly managing aquatic plants in an ecosystem context, we find much public opinion and many legislators against us. While the threat that exotic weeds pose for water resources may no longer be sufficient justification for control, there has been little effort devoted to examining the ecological and public health aspects of exotic infestations. If we are to continue to preserve, protect, and restore our Nation's water resources, we must demonstrate (with scientific data) the full range of problems caused by exotic species.

Funding for Aquatic Weed Control

John Thorne, Captiolink, Washington, DC

Uncontrolled growth of nuisance aquatic weeds disrupts natural ecosystems and threatens societal use of waterways across the United States. The need for weed control extends from water canals of the Southwest to the many reservoirs and lakes of the East. Although several safe and effective methods exist to restore these water bodies, funding for aquatic weed control is very limited. Realizing two years ago that states simply need funding to get the job done, Bill Culpepper and the SePRO Corporation retained me to identify Federal funding opportunities, lobby the White House and Congress to amend selected laws, and influence the budget decisions in Washington, D.C. to help states fund their efforts. A grassroots effort was begun to add clout to my efforts, and today water body managers and private citizens in 15 states provide much needed support through timely letters and telephone calls to Congress. The APMS is an important component of the grassroots program. With this cooperative effort, we saved the Corps of Engineers Aquatic Plant Control Program and are working to increase funding in that program. We are also working to amend the Water Resources Development Act, the Nonindigenous Aquatic Nuisance Prevention and Control Act, the Clean Water Act, and the Safe Drinking Water Act to provide specific, local opportunities for aquatic weed control funding.

The Future of Federal Support for Aquatic Weed Management

Faith Campbell, Exotic Pest Plant Council, Springfield, VA

Invasive exotic plants cause problems for ecosystems and water management systems worldwide. Costs of managing such invasions can be high: federal and

state agencies in Florida spend an estimated $30 million annually to manage aquatic and wetland weeds. Yet, understanding of exotic weeds' impact among political decision-makers and the public is so low that control programs must limp along with inadequate resources and scientific support. There are suggested steps the Aquatic Plant Management Society can take to increase the level of understanding among important decision-makers and those who influence public opinion. These steps will include becoming involved in coalitions forming across the Nation to prepare and distribute information for the lay person about the extent and impacts of alien plant invasions.

Chemical Control R&D: Government/Private Partnerships

Kurt D. Getsinger, US Army Engineer Waterways Experiment Station
Vicksburg, MS

The Corps of Engineers aquatic chemical control R&D expertise resides within the Aquatic Plant Control Research Program at the US Army Engineer Waterways Experiment Station (WES). The mission of this national R&D effort is to develop technology for improving the management of nuisance aquatic plants in an environmentally-compatible manner using herbicides and plant growth regulators. Work is conducted under laboratory, growth chamber and greenhouse conditions, and verified through mesocosm-, pond-, and field-scale studies. Recommendations are provided to field personnel for minimizing chemical dose while maximizing control of target plants. This approach reduces chemical loading in the environment and the effort/costs associated with aquatic applications, as well as minimizes damage to nontarget vegetation. The WES R&D team has developed working relationships and created a national coalition with the chemical industry, other Federal agencies (TVA, USBR, USDA, USFWS, USNBS), State/local natural resource management agencies, the academic community, and the general public. The team works closely with the USEPA Office of Pesticide Programs aquatic registration branch and various State pesticide regulatory groups. The future of managing aquatic plants with herbicides may well depend upon the survival of this national coalition and its ability to foster partnering among various levels of government and the private sector.

Customized Insurance Program for Aquatic Applicators and Companies

Michael H. Hall, Cobb-Hall Insurance, Howell, MI

The concept of this program is to provide adequate liability protection to people in the aquatic resource management industry. This includes applicators, harvesters, chemical sales, water quality testing and consulting services. The program would be an exclusive, available only to the members of the Aquatic

Plant Management Society. This would give membership an advantage, and the society control and benefits. By having the support of the society we can interest one of the leading companies specializing in environmental insurance protection. Currently most insurance coverage forms purchased are the "boiler plate" type loaded with exclusions, such as pollution, products, and professional liability. We have also determined that the purchase of insurance is a "cost of doing business" with little chance for a claim being covered. We have developed specific forms, exclusive to your industry addressing these important "gaps" in coverage.

Vermont's Aquatic Plant Management Program

Holly Crosson, Lakes & Ponds Section, Vermont Department
of Environmental Conservation, Waterbury, VT

Eurasian watermilfoil (*Myriophyllum spicatum*), water chestnut (*Trapa natans*) and purple loosestrife (*Lythrum salicaria*) are three troublesome exotic plants that infest lakes, rivers and wetlands in Vermont. The state Department of Environmental Conservation's Aquatic Plant Management Program seeks to prevent or reduce the harmful environmental and socioeconomic effects of these and other plant species through an integrated approach that combines mechanical, biological, physical and chemical control methods, places emphasis on selective control to reduce impacts to nontarget organisms, and incorporates a strong spread prevention and public education component.

Biology, Ecology, and Management of Waterchestnut

John D. Madsen, USAEWES Lewisville Aquatic Ecosystem
Research Facility, Lewisville, TX

Waterchestnut (*Trapa natans* L.) is an exotic nuisance-forming aquatic plant common to New York and Vermont, originally from Asia. Waterchestnut is a true annual, overwintering only by seed, and forms a floating rosette attached to an underwater stem that is weakly rooted. Waterchestnut was originally introduced to Schenectady, New York in 1884, and spread to the nearby Mohawk and Hudson Rivers and Champlain barge canal, and from there to the Lake Champlain. The basic biology, ecology and management of this plant will be reviewed, including impacts on water quality and native plant communities. The object of successful management approaches for this species is to prevent seed production, and eventually deplete the seed bank.

Development of an Integrated Plant Management Plan for Lake George, NY

Kenneth J. Wagner, Fugro, Inc., Northborough, MA

Eurasian watermilfoil (*Myriophyllum spicatum*) was detected in 22,000 acre Lake George, NY in 1985 and has spread at a rate of 10 new sites per year despite efforts to physically control this plant. A comprehensive management plan was developed after careful examination of site features and evaluation of constraints. The plan incorporates hand and suction harvesting, benthic barriers, and fluridone treatments in accordance with features of the milfoil population at each targeted site and the attendant environmental considerations. A pilot fluridone treatment is planned for 1997 and will include several treatment approaches to overcome environmental constraints.

Biological Weed Control: Sleeping Beauty or Ugly Duckling?

Bernd Blossey, Department of Natural Resources, Cornell University, Ithaca, NY

The spread of non-indigenous plant species continues to be a major threat to North American ecosystems. The federal mandate to replace nonselective herbicides with environmentally sound, cost effective measures makes biological control an important management tool for the future. The principal barrier preventing greater acceptance of biological weed control has been the lack of predictability for a likely success. In particular, experimental evaluations quantifying the effectiveness of control agents in the field has rarely been attempted. Examples from the biological control program against purple loosestrife (*Lythrum salicaria*) will be provided to highlight how to move a project onto a fast track. This will be contrasted to the Eurasian watermilfoil control program.

Heterophylly in a Water Lily: Interacting Effects of [CO_2] with Sediment and Water Depth

John E. Titus, Department of Biological Sciences, Binghamton University, Binghamton, NY

A *Nuphar variegata* Durand population with abundant submersed leaves occurs in a naturally acidic pond with high [CO_2]. Factorial greenhouse experiments tested the effects of CO_2 enrichment at pH 5 on the production of submersed vs. floating leaves. *Nuphar* transplants were grown for 15 weeks on three natural sediments (acidic pond, anthropogenically acidified lake, alkaline lake) at one water depth, or on one sediment at each of two depths (35 cm and 70 cm). Conditions favoring submersed leaf vs. floating leaf production included high vs. low [CO_2], deeper vs. shallower water, and acidic pond sediment vs. acidic lake and alkaline lake sediment.

Littoral Zone Dynamics: The Accumulation and Retention of Sediments in Submerged Aquatic Macrophyte Beds

Glenn Benoy and Jacob Kalff, Department of Biology, McGill University, Montreal, Canada

Sediment accumulation is encouraged in the shallow regions of lakes by the presence of macrophyte beds. Weedbeds transform the typically high energy littoral environment into a low energy quiescent environment, enabling the sedimentation of particles from suspension. A cohort of biotic and abiotic factors were combined to model and predict rates of sediment accumulation (SAR) in the littoral zone. By dating sediment cores according to a known anthropogenic marker (stable Pb) SARs were found to be primarily driven by macrophyte biomass and growth form, followed by littoral slope and site exposure, though these abiotic measures were more pronounced at low biomass sites. Follow up analyses will be presented that characterize and quantify the accumulating material in terms of particle size and organic content.

Aquatic Plant Management Strategies: The Lake George Experience

Charles W. Boylen, Lawrence W. Eichler, Darrin Freshwater Institute, Rensselaer Polytechnic Institute, Troy, NY and James W. Sutherland, New York State Department of Conservation Albany, NY

Use of Lake George as a drinking water supply has limited lake management of Eurasian watermilfoil to techniques aimed at limiting its spread. Hand harvesting, suction dredging and benthic barrier reduced the number of unmanaged sites from 110 to 11. Suction harvesting reduced milfoil allowing return of native vegetation. At sites where benthic barrier was removed 1-2 years after installation, milfoil recolonized rapidly as did native species. Hand harvesting by SCUBA in areas of limited milfoil reduced the number of milfoil plants present in subsequent years. An integrated program based on reduced milfoil growth and long term commitment is necessary since none of the techniques employed were found to eliminate milfoil.

Phragmites
A Threat to Biodiversity in Vermont Wetlands

Alan Emerson and R. J. Villamil, Department of Natural Sciences, Trinity College of Vermont, Burlington, VT

Phragmites commiunis or the common reed has found its way to Vermont and may adversely impact the current biodiversity of our wetlands. This reed is alien to Vermont but has become well established over the past ten to fifteen years. It is a highly competitive plant that can eliminate all other forms of plant life where it has become established. It has an extensive system of rhi-

zomes that permit it to multiply rapidly and provides a ground cover that excludes cohabitation with other plants. Humans may well have brought this plant to Vermont and certainly promote its growth. *Phragmites* thrives in disturbed areas where most plants struggle, i.e. roadsides, gullies, and drainage ditches. For these reasons Chittenten county is the central point for its large colonies. Considerable construction and increased use of road salt permit the niche *Phragmites* needs to out compete native species. It is unlikely that we can eliminate *Phragmites* in Vermont. It has shown some promise in treatment of polluted wetlands. A combination of control methods might be used with harvesting and burning the most promising. Elected representatives and agencies must be alerted to the seriousness of this problem and speed that it must be resolved. We protect our wetlands from the bulldozers of development. In the near future *Phragmites* may be considered the bulldozer of nature.

The Potential for Biological Control of Eurasian Watermilfoil with the Weevil *Euhrychiopsis lecontei*: Work in the Upper Midwest

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

The weevil *Euhrychiopsis lecontei* is native to the upper midwest. The weevil is highly specific to milfoils and performs slightly better on exotic Eurasian watermilfoil than the native northern watermilfoil. In tank experiments, initial stocking densities of 10-40 adults/m^2 reduced milfoil shoot and root biomass in one month and reduced stem and root carbohydrate stores. Field monitoring suggests that weevil populations have not maintained adequate densities to effect longer term control at two sites, however, milfoil is slowly declining at a third site. Sunfish predation may be important, but more work identifying limiting factors is needed.

Taxonomic Studies of the Yellow Water Lilies

Donald J. Padgett, Donald H. Les*, and Garrett E. Crow, Department of Plant Biology, University of New Hampshire, Durham, NH and *Department of Ecology and Evolutionary Biology, University of Connecticut, Storrs, CT

Yellow water lilies are virtually ubiquitous in freshwaters of temperate North America and Eurasia. However, systematic studies of *Nuphar* (Nymphaeaceae) have been problematic, hindered primarily by extreme morphological variability and presumed hybridization. Previous taxonomic considerations proposed only two species and many infraspecific taxa. This perception of relationships is inconsistent with recent molecular and morphological analyses that indicate two major lineages within *Nuphar* that correspond biogeographically to an Old World/New World divergence. These results are used to argue for a taxonomic

reevaluation of *Nuphar* that abandons the common practice of treating most taxa as subspecies of *N. lutea*.

Aquatic Plant Training for Volunteer Water Quality Monitors

Elizabeth M. Herron, Linda T. Green, and Hope Lesson, URI Watershed Watch, Kingston, RI

University of Rhode Island Watershed Watch, a state-wide volunteer water quality monitoring program, developed and implemented an aquatic plant identification and mapping training course for volunteer monitors. The six session course relied on extensive hands-on training in both classroom and field settings. Through the use of repetitive identification of local species, volunteers were successfully taught to use field keys to identify common aquatic plants and to conduct aquatic plant surveys. In addition to maintaining volunteer interest through educational opportunities and challenges, the course helped to expand the extremely limited information available on aquatic plants in Rhode Island lakes and ponds.

Genetic Variation Among and Within Populations of *Neobeckia aquatica* (Eaton) Greene (Lake Cress), a Rare Triploid

John D. Gabel and Donald H. Les, Department of Ecology and Evolutionary Biology, University of Connecticut, Storrs, CT

Populations of the rare lake cress have declined precipitously. Minimal genetic diversity is expected for this triploid species whose reproduction is entirely vegetative. We conducted an allozyme and RAPD survey of lake cress populations to quantify their genetic composition. Allozyme and RAPD markers revealed considerable variation between populations; whereas, discrete RAPD phenotypes also identified novel ramets within populations. Despite the apparent lack of sexual reproduction in lake cress, a substantial level of genetic variation has arisen by somatic mutation. Conservationists and researchers attempting to restore populations by reintroduction may benefit from genetic screening of populations to evaluate ramet diversity.

A Biogeographic Perspective on Watermilfoil Declines: Additional Evidence for the Role of Herbivorous Weevils in Promoting Declines?

Robert Creed, Department of Biology, Hood College, Frederick, MD

Recent research suggests that a native, herbivorous weevil may play a major role in promoting Eurasian watermilfoil declines in N. America. When the location of other N. American watermilfoil declines is examined there appears to

be a nonrandom distribution of declines with the majority of the declines occurring in northern states and in Canadian provinces which is the original range of the weevil and its native host, northern watermilfoil. If other factors were important in producing declines (e.g., competition with native species, accumulation of toxins, changes in water clarity or sediment chemistry) one would not expect to see such a latitudinal bias in the location of declines.

Effects of Increased Inundation and *Spartina* Wrack Deposition on a Saltmarsh Plant Community

Patricia M. Tolley and Robert R. Christian, Department of Biology, East Carolina University, Greenville, NC

Increased sea-level rise may result in increased inundation time and frequency of natural disturbance events in high salt marsh communities. Inundation time and *Spartina* wrack deposition were experimentally manipulated in order to discern individual and combined effects of these factors on high marsh plant species (i.e., *Juncus roemerianus*, *Spartina patens*, and *Distichlis spicata*) at a fringing mainland marsh on the Eastern Shore of Virginia. Community response to increased inundation was species-specific. Increased inundation did not affect primary production of *J. roemerianus* but rate of growth decreased and rate of senescence increased. *S. patens* aboveground biomass was significantly reduced by increased inundation. Growth of *D. spicata* was inhibited only when it was colonizing bare areas. In contrast, the effect of wrack deposition was not species-specific, with all plants being significantly impacted by this disturbance. Recovery after wrack deposition was species-specific. *S. patens* and *D. spicata* recovered rapidly following wrack removal while *J. roemerianus* biomass was still significantly lower in post-wrack areas relative to nonwrack areas. Thus the high marsh plant community appears relatively insensitive to increased inundation and very responsive to the disturbance of wrack.

Growth of the Emersed Form of Hygrophila

David L. Sutton, Fort Lauderdale Research and Education Center, University of Florida-IFAS,Fort Lauderdale, FL

Hygrophila (*Hygrophila polysperma* (Roxb.) T. Anderson), also known as East Indian Hygrophila, is replacing Hydrilla (*Hydrilla verticillata* (L.f.) Royle) in South Florida. Hydrilla and Hygrophila were introduced for use in the aquatic ornamental industry in the 1950's, and naturalized soon after their introduction. However, Hygrophila problems have begun to occur only within the past few years. Little information is available on the causes for the increased growth of Hygrophila, but Hygrophila appears to be more resistant to

currently registered aquatic herbicides than is Hydrilla. Submersed plants of Hygrophila grow similarly to Hydrilla, but Hygrophila also produces an emersed form that may be a major source of vegetative material to infest an area. Information will be presented on growth rates of the emersed form of Hygrophila.

Phenology of Monoecious Hydrilla in Lake Gaston

Chad R. Coley and Stratford H. Kay, Department of Crop Science, North Carolina State University, Raleigh, NC

Tuber and turions of monoecious hydrilla are found to be dormant up to 12 C. Turion dormancy was broken at 13 C, and tuber dormancy was broken at 15 C. Rhizome and new tuber development began by late June. Heaviest tuber production and biomass occurred in July and August, just prior to female flower production. Male flowers occurred in September with new tuber formation ceasing by October. Turion formation occurred in early November with all biomass decayed by January. This phenological information could be used with environmental data to predict times when monoecious hydrilla at specific locations would be susceptible to management efforts.

Propagule Production and Viability in Submersed Macrophytes

John W. Barko and Dwilette G. McFarland, US Army Engineer Waterways Experiment Station, Vicksburg, MS

In ecological investigations of submersed aquatic plants great attention has been placed historically on environmental conditions affecting their growth (i.e., biomass production). Relatively little attention has been focused on conditions affecting propagule production and viability. Since the persistence of most submersed macrophytes depends upon recruitment from propagule pools (e.g., seeds, fragments, tubers, turions), much can be gained from better knowledge regarding the role of environmental conditions affecting propagule production and viability over time. For some species, e.g., Hydrilla, the effects of light, temperature, and photoperiod on propagule production have been fairly well described. However, for this particular species and most others, effects of a variety of additional environmental factors (e.g., water depth, sediment type, hydraulic transport, etc.) on propagule production need to be elucidated. In addition, effects of environmental factors on propagule viability in relation to physiological condition and dispersal need to be addressed.

Competitive Interaction Between Hydrilla and Vallisneria as Influenced by the Biological Control Agent *Hydrellia pakistanae*

T.K. Van, G.S. Wheeler, and T.D. Center, USDA/ARS Aquatic Plant Control Research Unit, Ft. Lauderdale, FL

Experiments were conducted in outdoor pools to evaluate the influence of the biological control agent *Hydrellia pakistanae* (Diptera: Ephydridae) on the competitive interaction between hydrilla and vallisneria. An additive experimental design was used with ratios (hydrilla:vallisneria) of 0:3, 0:9, 3:0, 3:3, 3:9, 9:0, 9:3, and 9:9. Experiments were replicated both in the presence and absence of the biological control agent *H. Pakistanae*. Results showed a significant change in the competitive interaction between hydrilla and vallisneria due to the biological control agent The ability of biocontrol agents to reduce the competitive advantage of an invasive species and allowing the restoration of plant community with more native species will be discussed.

The Importance of Chemistry, Behavior, and Phenotypic Plasticity in Evaluating *Euhrychiopsis lecontei* (Curculionidae) as a Biocontrol Agent for Eurasian Watermilfoil

Susan L. Solarz and Raymond M. Newman, Department of Fisheries and Wildlife, University of Minnesota, St. Paul, MN

We report the results of several experiments which help determine the biocontrol potential of the herbivore *Euhrychiopsis lecontei* for Eurasian watermilfoil (*Myriophyllum spicatum*). These include oviposition experiments, learning experiments, and the characterization of a hostplant attractant. Of 30 weevils tested, 21 (70%) oviposited on several watermilfoil species, demonstrating *E. lecontei* is a true watermilfoil specialist. *Euhrychiopsis lecontei* host rank order is influenced by rearing plant and we demonstrate that forced exposure can change this host rank order. This rearing-plant effect has led to *E. lecontei* biotypes which differ in hostplant preference and learning ability. Quantitative genetics will help reveal phenotypic plasticity in biotypes of *E. lecontei* which will help describe the host range expansion and biocontrol possibilities.

***Nuphar* (Spatterdock), a Neglected Native**

Ken Langeland, Brian Smith, and Neil Hill, Center for Aquatic Plants, Agronomy Department, University of Florida-IFAS, Gainesville, FL

Spatterdock (*Nuphar luteum*), a common aquatic macrophyte, utilized by many forms of wildlife and esteemed by anglers, practically disappeared form Lake Griffin between 1953 and 1992. Propagation from seeds collected from naturally occurring populations was found to be a potentially successful

method for reestablishment of spatterdock during a planned drawdown of this central Florida lake. Seed can be collected by: 1) picking mature fruit, orange to red mottles on the pericarp, 2) allowing fruit to ripen in water containment (1000-L concrete tanks) for one to two weeks and, 3) separating seed by skimming and rinsing away unwanted plant material. Seed germinated best (>80%) at 25 C and did not germinate below 12.5 C. Germination was also best when peat content of the medium was >33% w/w. Seedlings grown under <96% light reduction, using shade cloth, died. Seed stored wet for one month germinated at 75% without significant loss in viability, while seed stored at 5 C for six months dropped to 25%. In order to minimize damage to seedlings and to allow for variability in seedling development, it is suggested that the greatest potential for successful establishment will result from germinating large numbers of seed and transplanting the resulting "spatterdock sod."

The Comparative Efficacy of Triclopyr and Glyphosate to Control Purple Loosestrife (*Lythrum salicaria* L.) Under Field and Growth Room Conditions

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The efficacy of triclopyr and glyphosate to control *Lythrum salicaria* (purple loosestrife) was examined under both field and growth room conditions. Glyphosate and triclopyr formulations were compared on an equimolar basis. In the field studies, triclopyr was more effective on mature plants if applied at the early flowering stage whereas glyphosate was equally effective when applied at either early or late flowering. In the growth room studies triclopyr was more effective than glyphosate for control of *L. salicaria* seedlings. Also, in growth room studies, the phytotoxicity of triclopyr and glyphosate formulations to *L. salicaria* seedlings (just prior to blooming) was not influenced by flooding, particularly at the two highest rates of 250 and 1250 g (a.e.)/ha.

Direct Impacts of Navigation Traffic on Submersed Aquatic Macrophytes in the Upper Mississippi River System

Mike Stewart, Dwilette McFarland, Sandra Martin, and Don Ward, US Army Engineer Waterways Experiment Station, Vicksburg, MS

In an effort to evaluate the influence of waves and currents generated by navigation traffic on aquatic macrophyte communities in the UMR system following a near decade long decline, a study was conducted within a 2-D flume facility at WES. The submersed species, *Vallisneria americana* Michx. and *Myriophyllum spicatum* L., were exposed to eighteen treatment combinations of current velocity (0.00, 0.10, and 0.25 m/sec), wave height (0.1, 0.2, and 0.3 m), and wave period (3 and 5 seconds). Main response variables were numbers

of fragments and total fragment biomass. Fragment numbers in both species were affected significantly by velocity and wave height, with similarity in results between species. However, neither species exhibited biomass losses greater than 20 percent in any of the treatments, with most treatments affecting losses ~ 5 percent. Thus, losses in biomass due to fragmentation were considered minor. In *M. spicatum*, but not in *V. americana*, stem fragments provide great potential for propagule dispersal and establishment. Thus, the long- term consequence of plant damage from navigation-generated waves and currents may be more rapid recovery from decline by *M. spicatum* than by *V. americana* in the UMR system.

Selecting Submersed and Emergent Species for Phytoremediation of Explosives in Constructed Wetlands

Susan L. Sprecher, US Army Engineer Waterways Experiment Station, Vicksburg, MS, and Elly P.H. Best, AScI Corporation, Vicksburg, MS

The metabolic and ecological attributes of plant species are major design elements in phytoremediation wetlands constructed to remove contaminants from water or soil. Laboratory evaluations of 19 species for TNT and RDX removal from groundwater targeted wetland and aquatic plants with perenniality, high productivity, high leaf and root surface areas, etc. Where contaminated groundwaters were incubated with plants in static hydroponic culture for 10 days, TNT removal was accelerated over that in water sediment controls. Time from 2200 mg L-1 TNT to portable levels of 2 mg L-1 decreased from 60 days to between 6 and 12 days. Removal of RDX was much slower, and was inversely correlated to oxygen levels in water. The range of plant types found to be active in explosives remediation can be deployed among pond, marsh, and upland areas, to provide a level of year-round remediation efficacy.

Growth Modelling of Submerged Aquatic Macrophytes, and Application Possibilities

Elly P.H. Best, AScI Corporation, Vicksburg, MS, and William A. Boyd, US Army Engineer Waterways Experiment Station, Vicksburg, MS

Simulation models for the biomass dynamics of *Hydrilla verticillata* (dioecious biotype) and *Myriophyllum spicatum* are presented. Both models, HYDRIL and MILFO, are based on carbon flow within a 1 m^2 water column. They include several factors that affect biomass dynamics such as latitude, seasonal changes in climate, pH and oxygen effects on CO_2 assimilation rate at light saturation, wintering strategies, grazing (removal of aboveground and/or tuber biomass) and mechanical control (removal of aboveground biomass). Both have been calibrated for vegetation in relatively shallow (0.1-2.5 m

depth) hard water. The characteristics of community and site can be easily modified by the user. The models can be used as a tool to predict the dynamics of submerged plant communities with life cycles typical for hydrilla and milfoil. Running the models with different parameter values specific for any particular site and/or treatment, (e.g. biomass removal to a certain water depth) helps in gaining insight into the predominant mechanisms regulating submerged plant dynamics.

Species-Selective Control of Eurasian Watermilfoil with Triclopyr

R. Michael Smart*, Kurt D. Getsinger, US Army Engineer Waterways Experiment Station, Vicksburg, MS, Gary O. Dick, University of North Texas, Denton, TX and John G. Skogerboe, *USAEWES Lewisville Aquatic Ecosystem Research Facility, Lewisville, TX

Complete elimination of all aquatic vegetation is not generally good management for large, multipurpose waterbodies. By sparing non-problem native species, habitat and water quality benefits and preservation of the integrity of the ecosystem are maintained. As an added bonus, the proliferation of native plants occupies the niche formerly held by exotics, thereby increasing the period of control effectiveness. Aquatic herbicides with selective properties can often be used to achieve these objectives. Experimental applications of triclopyr to aquatic plant communities growing in outdoor mesocosms effectively controlled Eurasian watermilfoil, allowed native species to flourish, and improved environmental conditions and water quality.

Response of Eurasian Watermilfoil and the Native Plant Community to a Triclopyr Application in Lake Minnetonka, MN: One Year Posttreatment

John D. Madsen, USAEWES Lewisville Aquatic Ecosystem Research Facility, Lewisville, TX and Kurt D. Getsinger, US Army Engineer Waterways Experiment Station, Vicksburg, MS

As part of a dissipation study of triclopyr in Lake Minnetonka, MN, the response of Eurasian watermilfoil and the native plant community were evaluated at two treatment (2.5 mg L-l) and one reference sites one week before treatment (June 1994), six weeks (August 1994), and one year (August 1995) after treatment. Eurasian watermilfoil was virtually eliminated from both treatment plots at 6 weeks posttreatment. One year posttreatment, Eurasian watermilfoil biomass was significantly below pretreatment levels. Native plant biomass and diversity were at or above pretreatment levels one year posttreatment. Even at the maximum application rates, triclopyr is not only effective against Eurasian watermilfoil, but allows recovery of the native plant community in years following application.

Integrated Hydroacoustic/GPS System for Mapping Underwater Vegetation

Bruce M. Sabol, US Army Engineer Waterways Experiment Station, Vicksburg, MS

A low cost integrated electronic measurement system was developed using off-the-shelf digital hydroacoustic, global positioning system (GPS), geographic information system (GIS), and personal computer components to detect and characterize submersed aquatic vegetation before it is visible from the water's surface. It is operated from a small boat with a 2-person crew. Detection and mapping of depth and vegetation characteristics can be performed in near real time. The system appears to have a significant potential for use in the aquatic plant management field. The system and its use are described and mapping products are presented.

Establishing Native Vegetation in Southern Reservoirs: Why and How?

R.D. Doyle, R.M. Smart, USAEWES, Lewisville Aquatic Ecosystem Research Facility, Lewisville, TX and G.O. Dick, University of North Texas, Denton, TX

Aquatic plant management has historically been limited to controlling nuisance (often exotic) species, with little effort given to encouraging the growth of beneficial native plants. A healthy community of natives provides the benefits of macrophytes while avoiding the serious ecological and management problems associated with exotic species. A diverse native plant community increases the ecological complexity of reservoirs, provides resilience to moderate disturbances, and occupies niches which might otherwise be filled by problematic exotics. This presentation reviews ecological considerations for establishing native plants in man-made reservoirs and summarizes results of several restoration efforts. Our approach has focused on establishing "founder communities" within currently unvegetated reservoirs. Initial results show that such plant communities can be reliably established but that herbivory is often a significant deterrent to rapid expansion of the plants.

Use of Fluridone for Selectively Controlling Eurasian Watermilfoil in a Mixed Plant Community: Outdoor Mesocosm Studies

Michael D. Netherland and Kurt D. Getsinger, US Army Engineer Waterways Experiment Station, Vicksburg, MS

Mesocosm studies were conducted at Lewisville, Texas to evaluate selectivity of the herbicide fluridone in a mixed plant community consisting of the exotic species Eurasian watermilfoil and native species Vallisneria, Sago pondweed, Elodea, and American pondweed. Plants established during the summer were treated with fluridone at rates of 0, 5, 10, and 20 mg/L on April 15 at the

onset of active growth, and on May 15 when Eurasian watermilfoil reached the surface. Average fluridone half-life was approximately 35 days, in the water treatments of 10 and 20 mg/L reduced biomass of all species by >85% at 60 DAT and >95% at 84 DAT. Plants removed from the fluridone treated water at 60 DAT rapidly recovered from injury symptoms when placed in untreated water. Following die-back of planted vegetation, mesocosms were dominated by Southern pondweed which germinated from seed. The 5 mg/L treatments resulted in excellent control of milfoil and Elodea (90 to 100% reductions), whereas, Vallisneria, and Sago and American pondweeds greatly increased in biomass by 60 and 85 DAT. In contrast, untreated mesocosms were dominated by Eurasian watermilfoil and Elodea throughout the study, resulting in suppression or elimination of other species. Results indicate that fluridone has within season selective properties, but the range of concentrations between selective and nonselective control may be narrow.

Interactions Between Waterhyacinth and a Dilute Organic Acid

D.F. Spencer and G.G. Kasander, USDA-ARS Aquatic Weed Laboratory, Weed Science Program, UC-Davis, Davis, CA, and J.D. Madsen, USAEWES Lewisville Aquatic Ecosystem Research Facility, Lewisville, TX and C.S. Owens, AScI Corporation, Lewisville, TX

Waterhyacinth (*Eichhornia crassipes* (Mart.) Solms) may be a serious weed posing a threat to human health, food and power production, and navigation in more than 50 countries throughout the world. We evaluated the effects of dilute solutions of acetic acid (applied as vinegar) on growth of waterhyacinth plants in small-scale outdoor experiments and in a large-scale pond study. Acetic acid (at 2.5 or 5%) applied to the foliage inhibited growth of waterhyacinth plants as determined by changes in dry weight, number of flowers, and the number of green or brown leaves. Tissue carbon changes were small for treated and untreated plants, but tissue nitrogen levels increased in treated leaves. Acetic acid appears to disrupt leaf function rapidly enough that tissue nitrogen is not translocated to other plant parts. These results were observed for waterhyacinth plants collected at various times in the growing season, and from locations in northern California or central Texas. The microbial metabolite, acetic acid may be a potentially useful new method for controlling waterhyacinth.

Selective Control of Purple Loosestrife with Triclopyr

Linda S. Nelson, Kurt D. Getsinger and Jan E. Freedman, US Army Engineer Waterways Experiment Station, Vicksburg, MS

The triethylamine salt formulation (TEA) of the herbicide triclopyr was evaluated for its effectiveness against the exotic plant pest, purple loosestrife *(Lythrum salicaria L.)*, that had established in shoreline wetlands along the upper Mississippi River in Minnesota. Application of 0.75% and 1.0% TEA triclopyr significantly reduced percent cover of purple loosestrife at 10 WAT. Regrowth from rootcrowns was evident 10 WAT in areas treated with the perennial rootstock. Because triclopyr is selective for control of most herbaceous dicots, changes within the monocot/dicot plant community were determined. Compared with untreated plots, triclopyr-treated areas showed a significant decrease in the percent cover of all dicot species with a concurrent increase in desirable monocot species.

Architectural Effect of *Myriophyllum spicatum* and *Potamogeton nodosus* on the Diet of Largemouth Bass

Eric E. Dibble, Department of Wildlife and Fisheries, Mississippi State University, Mississippi State, MS and Sherry L. Harrel, US Army Engineer Waterways Experiment Station, Vicksburg, MS

Structural complexity in aquatic habitats impact foraging efficiency of fishes. Aquatic plants differ in morphology, and little is known about how these differences effect foraging of fishes. Pond experiments were conducted to measure foraging differences of Largemouth bass (*Micropterus salmoides*) between two macrophytic habitats. Two submersed plant species (*Potamogeton nodosus*, and *Myriophyllum spicatum*) were cultured as treatments and replicated three times in pond enclosures. Identical numbers of small prey fishes were introduced and macro invertebrates sampled to determine food availability. After a 5 day acclimation period for prey fishes, largemouth bass (with empty stomachs) were introduced into treatment enclosures and allowed to feed. Fish were retrieved 48 hrs later and stomach samples taken to evaluate diet. Significant differences in diet were noted between treatments, suggesting that aquatic plant types influenced foraging behavior of largemouth bass.

Effect of Bialaphos Application Rates, Methods and Surfactant Combinations on Waterhyacinth (*Eichhornia crassipes*)

E.O. Abusteit, Cairo University, Giza, Egypt, and F.T. Corbin and S.H. Kay, Department of Crop Science, North Carolina State University, Raleigh, NC

Microbially produced herbicide bialaphos, L-2-amino-4-[(hydroxy)(methyl) phosphinoyl]butyryl-L-alanyl-L-alanine, efficacy against waterhyacinth as

influenced by its rates, application methods and surfactant combinations was evaluated under controlled environmental conditions. Bialaphos rates were: 2.5, 5.0 and 7.5 Kg ai/ha. The lowest herbicidal rate was directly injected to waterhyacinth in contrast to its spray mixtures with the surfactants Cide-Kick II, X-77 and Induce. Check and H_20 injected treatments were included for comparison. A CRBD statistical design with 4 replications was implemented. Bialaphos efficacy at its lowest rate was greatly improved by its combination with Cide-Kick II followed by X-77 and Induce. That could be mainly due to the breakdown of the waxy cuticle on waterhyacinth.

Arsenal Aquatic Experimental Use Permit (EUP)

Joe Vissagio, American Cyanamid Company, Gainesville, FL

In 1995, EPA granted a 2 year aquatic EUP for Arsenal herbicide. Three thousand acres were approved, with 50 in Alabama, 950 in Florida, 950 in Louisiana, 50 in Mississippi, and 1000 in Texas. The EUP allowed researchers to gather information on the efficacy of Arsenal for brush and other general weeds found in and around non-crop aquatic areas, including non-irrigation drainage ditches and other areas where impounded water is present. In Florida, all acres were treated with the South Florida Water Management District to control melaleuca. In Lake Okeechobee and the Water Conservation areas in Broward County. In Texas, acres were treated with the Nature Conservancy, Jefferson County Drainage District and TU Electric to control tallow, alligator weed, cattails and other brush species. In Louisiana the majority of acres were treated to control willow and tallow. In 1996, EPA has approved a proposed change to increase the acres treated in the state of Florida from 950 to 2,950 primarily for melaleuca control. In addition, approval has been granted to add Georgia, Pennsylvania and South Carolina. Alabama will not be included for the 1996 season.

Reduced Rate Endothall Application for Controlling Sago Pondweed in High-Flow Environments

David Sisneros, Ecological Research and Investigations Work Group, US Bureau of Reclamation, Denver, CO

This study evaluated the feasibility and efficacy of delivering one-tenth of the maximum label rate of the herbicide endothall to control Sago pondweed *(Potamogeton pectinatus* L.*)* in flowing water. Recent studies by the U.S. Bureau of Reclamation and the U.S. Army Corps of Engineers indicate that metering technology could be more efficacious than traditional applications at higher label rates. In 1994 endothall was metered into a small Idaho irrigation canal at approximately 0.4 mg/L for 72 hours. Water samples were collected at 12 hour intervals up to 90 hours at 7 sampling sites. To determine herbicide

efficacy biomass samples were taken prior to herbicide application and at 21 and 41 days posttreatment from 5 locations. Data indicates residues approached or exceeded the target rate at sampling sites within the treated area. Treated biomass did show statistical difference to the control at 41 days posttreatment.

The Use of the Fluridone FasTEST as a New Management Tool to Optimize the Efficacy and Application of Sonar

Mark Mongin, SePRO Corporation, Carmel, IN

Final developmental efforts of an immunoassay to determine fluridone concentration in water have been completed. This test system, Fluridone FasTEST, provides an alternative to conventional chemical assay procedures. Fluridone FasTEST provides the plant manager/applicator an opportunity to accurately monitor the concentration of fluridone in the water and make adjustments necessary to maintain the optimum concentration of fluridone in the water over time. The potential use of this new technology and its development with Sonar will be discussed.

Development of Immunoassay Methods for Aquatic Herbicides

Dave Nardone, Ohmicron Environmental Diagnostics, Inc., Newtown, PA

Immunoassays (IA) for environmental residues have been shown to be cost effective, accurate, and easy to use. They have gained regulatory acceptance and are used in a wide capacity, such as food safety, soil remediation and water quality. Traditional testing methods for aquatic herbicides are complex, time-consuming and require extraction, derivitization and GC/MS determination. This talk will describe the benefits of three IA methods. IAs combine selective antibodies attached to solid supports with sensitive enzyme reactions to produce an analytical system capable of detecting very low levels of residues. Method performance data will be presented for a triclopyr assay, 3,5,6-trichloro-2-pyridinol a metabolic breakdown residue of triclopyr, and a fluridone assay.

Eurasian Watermilfoil in Lake Tahoe: A Threat to A National Treasure

L. W. J. Anderson and F. J. Ryan, USDA-ARS Aquatic Weed Laboratory, Weed Science Program, UC-Davis, Davis, CA

Aerial and boat surveys of Lake Tahoe conducted in 1995 revealed that several populations of *Myriophyllum spicatum* are established on the North Shore, some 30 km from heavily infested South Shore marina areas. Although populations in South Shore Tahoe Keys have been present since the 1960's,

populations in the lake proper are in areas of high boat traffic and near protective docks. These are probably recent incursions of pioneer plants resulting from dispersal of fragments via currents and boating-related activities. Lake Tahoe is unique, with an average depth of 1,000 ft and 122,000 surface acres. Water clarity has diminished from secchi depths of 120 ft. in 1972 to ca. 70 ft. presently. The continued spread of macrophytes to other sites will significantly affect littoral zone conditions and accelerate organic loading of shoreline sediments. These changes are likely to alter near pristine conditions of the littoral zone and exacerbate already worsening water clarity through nutrient cycling. Due to a multitude of state, federal and local jurisdictions governing Tahoe water quality and biota, reaching a consensus for milfoil management/eradication) may be cumbersome at best. Potential management strategies will be discussed as well as studies underway to better characterize *Myriophyllum* species through use of RAPDs.

The Effects of Multiple-year Treatments of Fluridone on Hydrilla and Native Plant Populations

Alison Fox and Bill Haller, Center for Aquatic Plants, Agronomy Department, University of Florida-IFAS, Gainesville, FL

Sections of the Withlacoochee River, Florida, were treated with fluridone in 1990, 1991, 1992, and 1994. Fluridone was applied during the spring at low rates of 10 to 15 ppb, over periods of 10 to 13 weeks. Data will be presented showing the long-term effects of these treatments in both removing hydrilla biomass and in depleting hydrilla tuber populations. The variable impacts of these types of treatments on native vegetation, such as nuphar, vallisneria, and strap-leaf sagittaria, will also be discussed.

Lake Seminole Hydrilla Action Plan: An Integrated Approach

Michael J. Eubanks, US Army Corps of Engineers, Mobile District, Mobile, AL

Lake Seminole, FL-GA-AL, a 37,500-acre lake, has significant aquatic plant problems. Hydrilla (*Hydrilla verticillata*), the major problem plant, causes serious water resource problems, as it increased to a maximum of 24,000 acres in 1992. A number of aquatic plant management techniques have been utilized; however, herbicide applications have been the most effective technique demonstrated to date. Based on a special Congressional directive, the Corps is developing a Hydrilla Action Plan. Alternatives discussed initially but eliminated from detailed analysis included mechanical control; biological control with insects or pathogens; unconfined release of grass carp; and lake drawdown. Alternatives presented in the final array include: a) no action; b)

traditional herbicide program; c) confined grass carp stocking (subject of large demonstration test); d) herbicide drip delivery system; and, e) integrated hydrilla management (combination from alternatives b), c), and d). This combination alternative is the draft recommended plan, which was coordinated with the public in a draft report in March 1996. Implementation of this plan would result in control of hydrilla at the priority management areas and reduces the total hydrilla acreage to approximately 14,000 acres. The presentation summarizes the comments received on the draft report and provides the status of the confined grass carp demonstration test.

Selective Aquatic Plant Management with Sonar Aquatic Herbicide
Craig S. Smith and G. Douglas Pullman, Aquest Corporation, Flint, MI

Sonar aquatic herbicide has proven to be extremely effective for the control of Eurasian watermilfoil and curly leaf pondweed in Michigan inland lakes since 1990. The stated goal of most Sonar-based lake management programs was a reduction in nuisance plant growth and restoration of native aquatic plant community. Management strategies were designed to reduce the production of target species with minimal impact on the production of desirable plant and algal species. Evaluation of vegetation survey data from Michigan lakes treated with Sonar from 1990 through 1995 revealed that plant species responses to Sonar approximate standard dose rate response curves and that many native aquatic plant species are less sensitive to Sonar than Eurasian watermilfoil or curly leaf pondweed. Thus, at low dose rates Sonar can be used for reasonably selective nuisance plant control. Refinements in application methodologies, dose rate determination techniques, and the timing of applications can be used to enhance the selectivity of Sonar applications.

Aquatic Dissipation of Triclopyr in a Whole-Pond Treatment
John G. Skogerboe, USAEWES Lewisville Aquatic Ecosystem Research Facility, Lewisville, TX, Kurt D. Getsinger, US Army Engineer Waterways Experiment Station, Vicksburg, MS and David G. Petty, DowElanco, Indianapolis, IN

Triclopyr is a selective, systemic herbicide registered for use in the control of broadleaf weeds in upland, non-crop areas. A registration is currently being sought for use in the control of nuisance aquatic plants. In order to satisfy EPA Guidelines 164-2 and 165-5, a study was conducted at the Lewisville Aquatic Ecosystem Research Facility under "GLP" to quantify aquatic dissipation of triclopyr in a whole-pond treatment. The objective was to establish dissipation curves for triclopyr and its metabolite, pyridinol in water, sediment, and fish. An overview of the study objectives, methodology, and facilities will be presented.

The Use of Information/Expert Systems for Technology Transfer Activities
Michael J. Grodowitz, US Army Engineer Waterways Experiment Station, Vicksburg, MS

Before implementing a management program on noxious and nuisance aquatic plants, information must be obtained on: 1) ecology and biology of the target species, 2) impacts to the environment, and 3) available management options. Various "traditional" information sources on noxious and nuisance plant management are available and include technical publications, oral presentations, video recordings and training courses. However, the task of obtaining and summarizing this information is extremely difficult considering the enormous number of publications needed to implement a single management strategy. A more efficient method of information exchange is needed. Toward this goal, we have developed several computer-based information/expert systems that allow easy and rapid access to a variety of information on pest identification, biology, and pertinent management techniques. These systems are PC-based and run under the Windows environment. Windows provides a highly intuitive graphical interface and a high degree of portability which allow the systems to operate on machines with vastly different hardware configurations. The systems incorporate a variety of media types for information access including photographic images, illustrations, and hyper-linked text. Use of computer-based applications provides a particularly effective and rapid way of transferring important information on noxious and nuisance plant management.