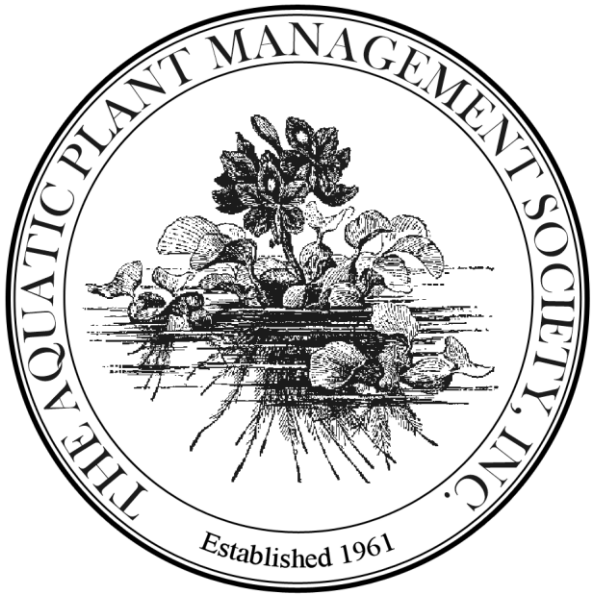
56th Annual Meeting of the Aquatic Plant Management Society

Program & Abstracts

Amway Grand Plaza Hotel
Grand Rapids, Michigan
July 17-20, 2016



The Aquatic Plant Management Society, Inc. is an international organization of scientists, educators, students, commercial pesticide applicators, administrators, and concerned individuals interested in the management and study of aquatic plants. The membership reflects a diversity of federal, state, and local agencies, universities and colleges around the world, corporations, and small businesses. Membership applications are available at the meeting registration desk.

The Objectives of the Society are to assist in promoting the management of nuisance aquatic plants, to provide for the scientific advancement of members of the Society, to encourage scientific research, to promote university scholarships, and to extend and develop public interest in the aquatic plant science discipline.

Our Mission: Promote environmental stewardship through scientific innovation and development of technology related to integrated plant management in aquatic and riparian systems.

The Aquatic Plant Management Society thanks Duke Energy Carolinas for their generous contribution to print and distribute the Program for the 56th Annual Meeting!

DUKE ENERGY.

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Scholastic Endowment	Tom Warmuth
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RISE	Sam Barrick
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APMS Presidents and Meeting Sites

1961	T. Wayne Miller, Jr.	Fort Lauderdale, FL
1962	T. Wayne Miller, Jr.	Fort Lauderdale, FL
1963	William Dryden	Tampa, FL
1964	Herbert J. Friedman	Tallahassee, FL
1965	John W. Woods	Palm Beach, FL
1966	Zeb Grant	Lakeland, FL
1967	James D. Gorman	Fort Myers, FL
1968	Robert D. Blackburn	Winter Park, FL
1969	Frank L. Wilson	West Palm Beach, FL
1970	Paul R. Cohee	Huntsville, AL
1971	Stanley C. Abramson	Tampa, FL
1972	Robert J. Gates	Miami Springs, FL
1973	Brandt G. Watson	New Orleans, LA
1974	Alva P. Burkhalter	Winter Park, FL
1975	Luciano Val Guerra	San Antonio, TX
1976	Ray A. Spirnock	Fort Lauderdale, FL
1977	Robert W. Geiger	Minneapolis, MN
1978	Donald V. Lee	Jacksonville, FL
1979	Julian J. Raynes	Chattanooga, TN
1980	William N. Rushing	Sarasota, FL
1981	Nelson Virden	Jackson, MS
1982	Roy L. Clark	Las Vegas, NV
1983	Emory E. McKeithen	Lake Buena Vista, FL
1984	A. Leon Bates	Richmond, VA
1985	Max C. McCowen	Vancouver, BC
1986	Lars W. J. Anderson	Sarasota, FL
1987	Dean F. Martin	Savannah, GA
1988	Richard D. Comes	New Orleans, LA
1989	Richard Couch	Scottsdale, AZ
1990	David L. Sutton	Mobile, AL
1991	Joseph C. Joyce	Dearborn, MI
1992	Randall K. Stocker	Daytona Beach, FL
1993	Clarke Hudson	Charleston, SC
1994	S. Joseph Zolczynski	San Antonio, TX
1995	Steven J. de Kozlowski	Bellevue, WA
1996	Terence M. McNabb	Burlington, VT
1997	Kurt D. Getsinger	Fort Myers, FL
1998	Alison M. Fox	Memphis, TN
1999	David F. Spencer	Asheville, NC
2000	J. Lewis Decell	San Diego, CA
2001	Jim Schmidt	Minneapolis, MN
2002	David P. Tarver	Keystone, CO
2003	Richard M. Hinterman	Portland, ME
2004	Ken L. Manuel	Tampa, FL
2005	Eric P. Barkemeyer	San Antonio, TX
2006	Jeffrey D. Schardt	Portland, OR
2007	Donald W. Doggett	Nashville, TN
2008	Jim Petta	Charleston, SC
2009	Carlton Layne	Milwaukee, WI
2010	Greg MacDonald	Bonita Springs, FL
2011	Linda Nelson	Baltimore, MD
2012	Tyler Koschnick	Salt Lake City, UT
2013	Terry Goldsby	San Antonio, TX
2014	Mike Netherland	Savannah, GA
2015	Cody Gray	Myrtle Beach, SC
2016	Rob Richardson	Grand Rapids, MI

APMS Award Recipients

Honorary Members (year of honor)

Awarded to persons who have been voting members of the Society for no less than ten years, have contributed significantly to the field of aquatic vegetation management, and must have actively promoted the Society and its affairs during their membership.

William E. Wunderlich	1967
F. L. Timmons	1970
Walter A. Dun	1976
Frank S. Stafford	1981
Robert J. Gates	1984
Herbert J. Friedman	1987
John E. Gallagher	1988
Luciano “Lou” Gallagher	1988
Max C. McCowen	1989
James D. Gorman	1995
T. Wayne Miller, Jr.	1995
A. Leon Bates	1997
Richard Couch	1997
N. Rushing	1997
Alva P. Burkhalter	2002
J. Lewis Decell	2004
Paul C. Myers	2005
David L. Sutton	2006
Dean F. Martin	2007
Robert C. Gunkel, Jr.	2008
Allison M. Fox	2010
Randall K. Stocker	2010
Steven J. de Kozlowski	2010
Carole Lembi	2011
Lars W.J. Anderson	2012
David Tarver	2012
Don Doggett	2013
Richard Hinterman	2013
David Spencer	2015

President’s Award (year of award)

An individual, designated by the current President, who has displayed "*Many Years of Dedication and Contributions to the Society and the Field of Aquatic Plant Management*".

T. O. “Dale” Robson	1984
Gloria Rushing	1991
William T. Haller	1999
David Mitchell	1999
Jeffrey D. Schardt	2002
Jim Schmidt	2003
Robert C. Gunkel, Jr.	2004
Victor A. Ramey	2006
William H. Culpepper	2007
Kurt Getsinger	2008
Richard Hinterman	2009
Steve D. Cockreham	2010
Donald W. Doggett	2012
Carlton Layne	2013
Ken Langeland, Jeff Schardt, Dan Thayer, Bill Zattau	2014
Greg MacDonald	2015
Linda Nelson	2015

Max McCowen Friendship Award (year of award)

Judy McCowen	1995
John E. Gallagher	1997
Paul C. Myers	2000
William T. Haller	2002
Bill Moore	2006
Vernon V. Vandiver, Jr.	2012
Tommy Bowen	2014
Steve Hoyle	2015

A special recognition given to an APMS member whose demeanor and actions display sincerity and friendship in the spirit of being an ambassador for the APMS. Criteria include warmth and outgoing friendship, sincerity and genuine concern, gracious hospitality, positive attitude/smile.

T. Wayne Miller Distinguished Service Award (year of award)

Gerald Adrian	2005
Linda Nelson	2007
Surrey Jacobs	2009
Amy Richard	2010
Michael Netherland	2011
John H. Rodgers, Jr.	2012
John Madsen	2013
Jim Schmidt	2014
Jeffrey D. Schardt	2015

An individual recognized for *"Service to the Society and the Profession"*. Considerations include completion of a relatively short-term project taking considerable effort resulting in advancement of aquatic plant management; performance beyond the call of duty as an APMS officer, chair, or representative; or non-member achievement leading to the advancement of APMS goals and objectives.

Outstanding Graduate Student Award (year of award)

Ryan Wersal	Mississippi State University	2010
Joe Vassios	Colorado State University	2011
Sarah True-Meadows	North Carolina State University	2013
Justin Nawrocki	North Carolina State University	2014
Erika Haug	North Carolina State University	2015

A student recognized for outstanding achievement during graduate studies in the field of aquatic plant management.

Outstanding International Contribution Award (year of award)

Deborah Hofstra	National Institute of Water and Atmospheric Research	2013

An individual or group recognized for completion of research or outreach activities that are international in nature.

Outstanding Journal of Aquatic Plant Management Article Award (year of award)

James Johnson, Ray Newman	University of Minnesota	2012
Michael D. Netherland and LeeAnn Glomski	U.S. Army Corps of Engineers	2014

An award voted by the Editor and Associate Editors for research published in the JAPM during the previous year.

Outstanding Research/Technical Contributor Award (year of award)

Michael D. Netherland, Dean Jones, Jeremy Slade	2010
Kurt Getsinger	2011
Mark Heilman	2013
John Rodgers	2015

An individual or group recognized for completion of a research project or technical contribution related to aquatic plant management that constitutes a significant advancement to the field.

APMS Graduate Student Research Grant (year and amount of grant)

Student initiatives are among the most important core values of the Aquatic Plant Management Society. High on the list of student support programs is the Graduate Student Research Grant offered by APMS in the area of aquatic plant management and ecology. This academic grant is co-sponsored by APMS and the seven regional APMS chapters: Florida, MidSouth, Midwest, Northeast, South Carolina, Texas, and Western.

The $40,000 Graduate Student Research Grant is awarded every two years for the most qualified proposal submitted. The objective is to provide a grant for a full-time graduate student to conduct research in an area involving aquatic plant management techniques (used alone or integrated with other management approaches) or in aquatic ecology related to the biology or management of regionally or nationally recognized nuisance aquatic vegetation.

Recipient	Affiliation	Year	Amount
Mary Bremigan	Michigan State University	1999	$34,000
The Indirect Effects of Sonar Application on Lake Food Webs			
Katia Englehardt	University of Maryland	2001	$40,000
Controlling Non-native Submersed Aquatic Macrophyte Species in Maryland Reservoirs: Plant Competition Mediated by Selective Control			
Susan Wilde	University of South Carolina	2005	$40,000
Investigating the Role of Invasive Aquatic Plants and Epiphytic Cyanobacteria on Expression of Avian Vacuolar Myelinopathy (AVM)			
John Madsen and Ryan Wersal	Mississippi State University	2007	$60,000
The Seasonal Phenology, Ecology and Management of Parrotfeather [Myriophyllum aquaticum (Vellozo) Verdecourt]			
Rob Richardson, Sarah True, and Steve Hoyle	North Carolina State University	2010	$40,000
Monoecious Hydrilla: Phenology and Competition			
Ryan Thum	Grand Valley State University	2012	$40,000
A Quantitative Genetics Approach to Identifying the Genetic Architecture of Herbicide Susceptibility, Tolerance, and Resistance in Hybrid Watermilfoils (Myriophyllum spicatum x sibiricum)			
Scott Nissen	Colorado State University	2014	$40,000
Exploring the Physiological Basis of 2,4-D Tolerance in Northern Watermilfoil x Eurasian Watermilfoil Hybrids			
Rob Richardson	North Carolina State University	2015	$40,000
Aspects of Monoecious Hydrilla Physiology and Response to Herbicide Combination Treatments			

Sustaining Members

Alligare, LLC is a leading supplier in industrial vegetation management and a subsidiary of ADAMA, the world's largest manufacturer of post patent crop protection chemicals. Our markets include vegetation management, forestry, right-of-way, range and pasture, and aquatics. Alligare works directly with manufacturers around the world to bring the highest level of product quality and service to our customer. Alligare Specialists provide product and service faster and more cost effectively than a traditional sales force.

Since 1981, **Applied Aquatic Management, Inc**., (AAM) has provided innovative and effective water management services, selective vegetation control, wetland management and exotic weed control. AAM has clients throughout Florida including developers, homeowners associations, golf courses, mobile home communities, utilities, local, state and federal government agencies and industry. Our experienced professional staff provides unique knowledge along with advanced equipment to manage all types of waterway, right-of-way, wetland, and upland systems.

Aqua Services, Inc. is a full-service, aquatic resource management company that specializes in aquatic vegetation management. Established in 1983, the company has provided aquatic plant management for entities in the southeastern U.S. that include the Corps of Engineers, Tennessee Valley Authority, Southern Company, and the Tennessee Wildlife Resource Agency. Aqua Services also provides lake management consulting including electro-fishing assessments, water quality analysis and enhancement, and recreational lake design.

AquaTechnex, LLC is a lake and aquatic plant management firm that operates in the Western United States. The company is expert in the use of aerial and boat GIS/GPS technologies to assess aquatic environments. The firm is also expert in the management of invasive aquatic weed species and phosphorous mitigation to suppress toxic cyanobacteria blooms. Our web site is www.aquatechnex.com; please drop by regularly to get news updates as we have moved our blog onto the site.

Aquatic Control, Inc. has been managing aquatic resources since 1966. As a distributor of lake management supplies, floating fountain aerators, and diffused aeration systems, Aquatic Control represents Applied Biochemists, AquaBlok, BioSafe Systems, Brewer International, SePRO, Syngenta, United Phosphorus, AquaMaster, Kasco, and Otterbine. Aquatic Control has five offices that offer aquatic vegetation management plans including vegetation mapping and application services, fountain and aeration system installation, maintenance, and service throughout the Midwest.

BioSafe Systems LLC has been offering sustainable and effective solutions for lake management, municipal and wastewater treatments and other water resources since 1998. Our uniquely balanced, broad-spectrum chemistries are designed to enhance your water's health, quality and appearance. Alternatives to products that utilize copper, or other harsh and sometimes toxic chemicals, BioSafe Systems' complete line of products are EPA registered, USDA NOP compliant, OMRI listed and effectively alleviate algal issues with minimal impact on the environment.

Brewer International, located in Vero Beach, Florida, has been a chemical manufacturer since 1973. This location is perfect because the company purchases limonene, a low viscosity oil derived from the peel of citrus fruit. This natural ingredient is used in many of Brewer's formulations including two OMRI Listed Organic surfactants: Organic-Kick and Vin-Kick. The company offers aquatic surfactants Cide-Kick, Cide-Kick II, Cygnet Plus, I'Vod, Sun Wet, and Poly Control 2. Check out our web site at www.brewerint.com and visit us on our Facebook page.

Sustaining Members

Chem One is a national leader of Organic Copper Sulfate for aquatic management. With eight standard EPA label grades; Fine 20, 25, 30, 100, 200, Small, Medium and Large. Chem One has a grade to meet every customer's needs. With our corporate offices and 78,000+ square foot warehouse in Houston, Texas, Chem One is a national wholesale company that is certified to ISO 9001, ISO 14001, OHSAS 18001.

Clarke Aquatic Services is a global environmental products and services company. Our mission is to make communities around the world more livable, safe, and comfortable. By understanding our customers' needs, we tailor service programs that draw on our unmatched breadth of industry experience, expertise, and resources. We pioneer, develop and deliver environmentally responsible mosquito control and aquatic services to help control nuisances, prevent disease, and create healthy waterways.

Crop Production Services, Inc. (CPS) is a national distributor dedicated to providing innovative solutions and quality products for our customers in the aquatic industry. With our experienced sales force and national warehouse network, CPS provides fast, reliable access to the products our customers need, the services our customers want, and emerging technologies that will address vegetation management needs today and into the future. At CPS, we work closely with customers to develop solutions for their vegetation management programs.

Cygnet Enterprises, Inc. is a national single source distributor of aquatic management products with offices and warehouses in Michigan, Indiana, Pennsylvania, North Carolina, California and Idaho. Cygnet is proud of its reputation for outstanding service, friendly, knowledgeable staff and our unmatched support of the aquatics industry. Cygnet Enterprises is the only aquatic distributor at the Charter Gold Member level in the Aquatic Ecosystem Restoration Foundation (AERF). Please visit www.cygnetenterprises.com.

Duke Energy is one of the largest electric power holding companies in the U.S. Its regulated utility operations serve approximately 7.4 million electric customers located in six states in the Southeast and Midwest, representing a population of approximately 24 million people. Its Commercial Portfolio and International business segments own and operate diverse power generation assets in North America and Latin America, including a growing portfolio of renewable energy assets in the U.S. Headquartered in Charlotte, NC, Duke Energy is an S&P 100 Stock Index company traded on the New York Stock Exchange under the symbol DUK. Visit us at duke-energy.com.

Lake Restoration produces products for lakes & ponds including: Mizzen algaecide, LAKEMAID, Goose D-Fence, Sapphire Bay pond dye, and MuckMaid. Mizzen is a copper based algaecide. The patented LAKEMAID eliminates lake weeds automatically. The Goose D-Fence is a retractable solution for goose problems. Founded in 1977, Lake Restoration is based in Minnesota. For more information, visit our website www.lakerestoration.com.

The **Lee County Hyacinth Control District** was formed by the Florida Legislature in June 1961to curtail excessive growths of water hyacinth. That same year, water managers from across the state convened in Lee County and formed the Hyacinth Control Society, now APMS, to share control strategies and develop a comprehensive management approach to Florida's most prolific aquatic plant. T. Wayne Miller, Jr. of Lee County served as the Society's President for the first two years and Lee County has been a supporting member of APMS since its inception.

Sustaining Members

Applied Biochemists® team at Lonza Water Treatment is proud of its active membership and participation with the APMS for over 40 years. As a manufacturer and supplier of algaecides, aquatic herbicides and other water management products, we highly value the science and integrity the APMS brings to our industry. We are a leading life sciences company, dedicated to the development, production and application of a wide variety of products to improve the recreational and functional value of water, and quality of life throughout the world.

Pond Boss PRO, a division of the OASE group, provides a line of professional grade products specifically formulated to effectively and rapidly deal with challenges associated with large bodies of fresh water. Our products and innovation will clean, clear, condition and balance water chemistry allowing lakes to be enjoyed the way nature intended. www.thepondboss.net From container gardens to the backyard Oasis and the management of lakes and watersheds, "Living Water" is OASE's passion. www.oase-livingwater.com

Founded more than 75 years ago as the South Carolina Public Service Authority, **Santee Cooper** is a reliable, recognized leader in energy generation and water utility services. Our aquatic plant management program began in the early 1940s and is now one of the largest programs in the southeastern U.S., providing invasive plant control over 160,000 surface acres including Lakes Marion and Moultrie. We are a proud founding member of the South Carolina Aquatic Plant Management Society.

For 22 years, **SePRO Corporation** has developed innovative technologies to advance the science of water management. The SePRO team provides comprehensive assessment, planning and implementation solutions. Our focused disciplines include aquatic plant and algae management, water quality restoration, laboratory analysis, mapping and data management. Whether you are looking to assess a water resource, design a prescription plan or implement a restoration program, SePRO provides expertise and solutions to preserve our most precious natural resource – water. www.sepro.com

Invasive weeds can devastate both natural and commercial habitats. **Syngenta** provides high performance products to control destructive weeds while helping to restore the habitat of aquatic environments. Syngenta offers proven aquatic herbicides like Reward® and Tribune™ that provide fast burn-down, work well in cool weather and are rainfast in as little as 30 minutes. The active ingredient, diquat dibromide, has been used successfully in sensitive aquatic areas for over 25 years.

UPI manufactures and markets aquatic herbicides and algaecides for lakes, ponds and irrigation canals. These products are marketed as Aquathol®, Hydrothol®, AquaStrike®, Current®, Symmetry®, Cascade® and Teton®. UPI is a leader in the development of new uses, techniques and formulations to improve aquatic plant management strategies. UPI is a worldwide producer of crop protection products with U.S. operations based in King of Prussia, PA. For more information, please visit www.upi-usa.com or www.cascadeforcanals.com.

Vertex Water Features is a science and engineering based aeration system manufacturer that provides custom designed water quality solutions distributed through its lake manager dealer network to interested lake owners, lake managers, developers and government agencies throughout North America and internationally. Website: www.vertexwaterfeatures.com. Phone: 1-844-432-4303, Email info@vertexwaterfeatures.com, FB: https://www.facebook.com/VertexWaterFeatures/

Meeting Sponsors

The Aquatic Plant Management Society appreciates the generous support of the following meeting sponsors. Through their support and contributions, we are able to conduct a successful and enjoyable meeting. Our 2016 Sponsors when the Program went to print on June 24, 2016.

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Fayetteville, GA

Santee Cooper
Moncks Corner, South Carolina

Vertex Water Features
Pompano Beach, Florida

Exhibitors

The Aquatic Plant Management Society thanks the following companies for exhibiting their products and services. This list was current when the Program was printed on June 24, 2016. Please visit the exhibit hall in Ambassador Ballroom East for all Exhibitors, including not-for-profit organizations.

Airmax Ecosystems, Inc.
Romeo, Michigan

Alligare, LLC
Davidson, North Carolina

Aquatic Control, Inc.
Seymour, Indiana

BioSafe Systems, LLC
East Hartford, Connecticut

Brandt Consolidated, Inc.
Springfield, Illinois

Brewer International
Vero Beach, Florida

Clean Lakes, Inc.
Martinez, California

Crop Production Services
Oviedo, Florida

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SePRO Corporation
Carmel, Indiana

Syngenta
Royal Palm Beach, Florida

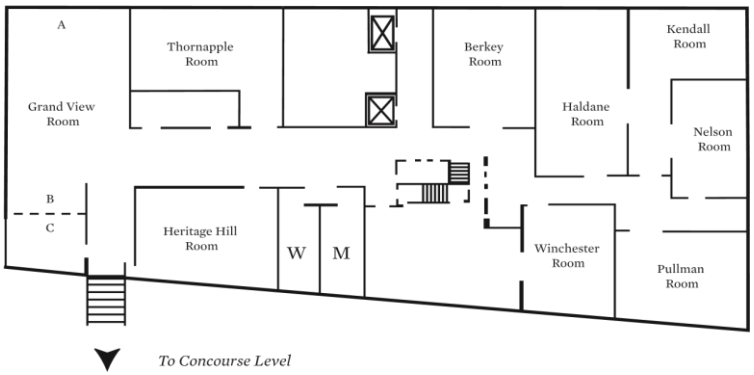
TRM, Incorporated – Bio-Zyme
New Smyrna Beach, Florida

UPI
Exton, Pennsylvania

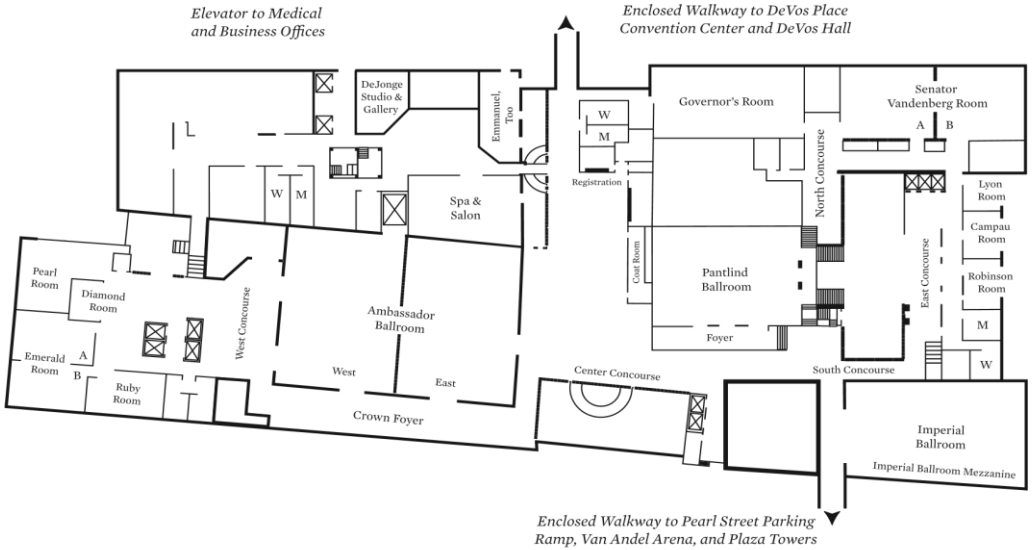
Vertex Water Features
Pompano Beach, Florida

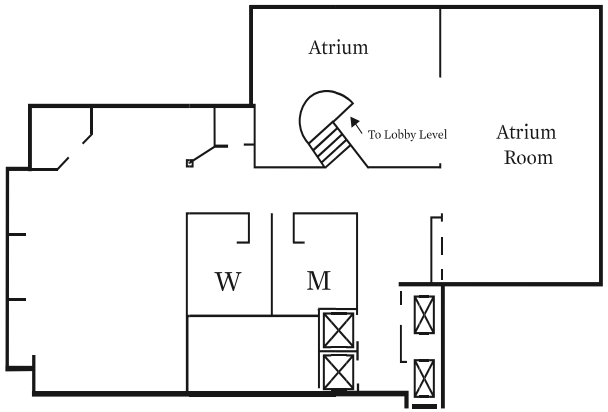
Winfield
Ville Platte, Louisiana

CONFERENCE LEVEL – 3RD FLOOR

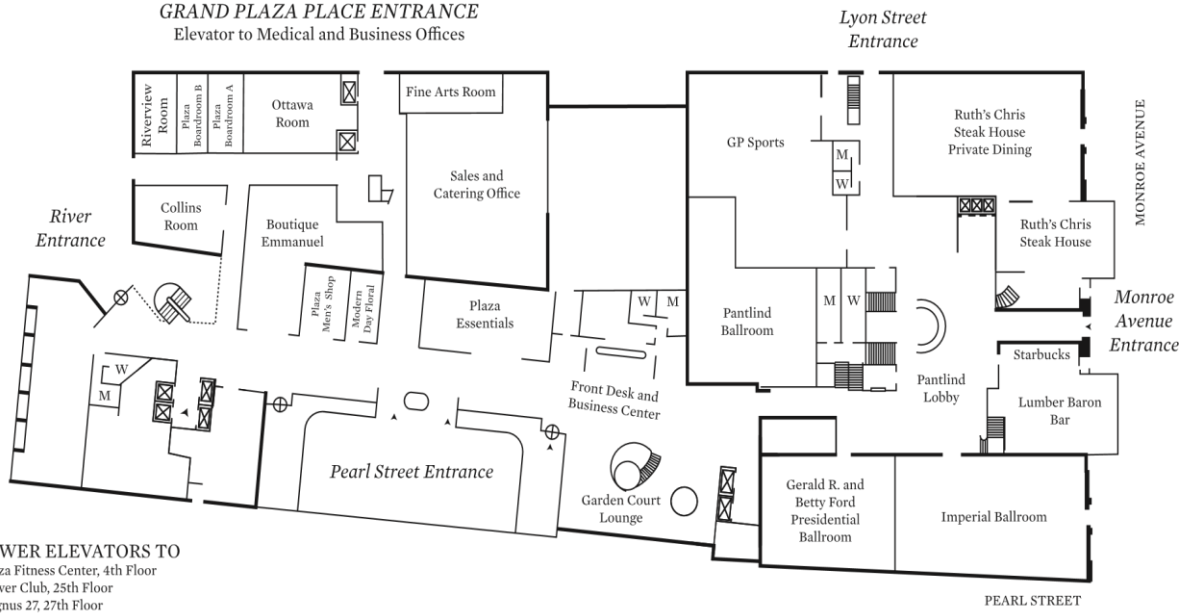


CONCOURSE LEVEL – 2ND FLOOR





LOBBY LEVEL – 1ST FLOOR



TOWER ELEVATORS TO
- Plaza Fitness Center, 4th Floor
- Tower Club, 25th Floor
- Cygnus 27, 27th Floor
- Sky I & II, Private Dining Rooms, 28th Floor
- Pinnacle Room, Take to 28th Floor

General Information and Events

Program Organization

The Agenda is organized by day and time. Posters and abstracts are organized alphabetically by presenting author. For more event information, please see the Agenda-at-a-Glance pages for each day in this Program. Messages will be posted at the meeting registration desk.

Name Badges

Your name badge is your ticket for all events and functions at the meeting. Wear it to all activities during the meeting. All individuals participating in meeting events or activities must be registered and have a name badge. Non-registered guests may purchase tickets for the President's Reception, Guest Tour, Poster Session Reception, and Awards Banquet at the meeting registration desk.

Meeting Registration Desk

The meeting registration desk will be located in the Crown Foyer in front of the Ambassador Ballrooms, Concourse Level, 2nd Floor, for the duration of the meeting.

Exhibits

Exhibits will be open from 7:00 p.m. Sunday to 10:00 a.m. Wednesday in Ambassador Ballroom East.

Posters

Posters will be open from 7:00 p.m. Sunday to 10:00 a.m. Wednesday in Ambassador Ballroom East. Poster presenters will be on hand during the Monday evening Poster Reception as well as during breaks to answer questions.

Continental Breakfasts / Refreshment Breaks

Continental breakfasts and mid-morning and afternoon refreshment breaks will be served each day in Ambassador Ballroom East. Please see the Agenda-at-a-Glance for specific times. Also take time to visit with Exhibitors in Ambassador Ballroom East while enjoying your breakfast or break.

Spur of the Moment Meeting Room

We have a room set up conference style for 25 guests. Please check at the meeting registration desk to reserve.

Student Meet and Greet: *Sunday, July 17, 6:00 p.m. to 7:00 p.m., Garden Court – Lobby Level*

All registered students are invited to gather and meet at the Garden Court, Lobby Level, with other students prior to the Presidents' Reception.

President's Reception: *Sunday, July 17, 7:00 p.m. to 9:00 p.m., Gerald R. Ford Presidential Ballroom Room*

Join your APMS friends and colleagues at this gathering to "kick-off" our annual meeting while enjoying hors d'oeuvres and beverages. The President's Reception is open to all registered delegates, guests, and students. Non-registered guests may purchase tickets at the meeting registration desk.

Guest Tour: *Monday, July 18, 10:00 a.m. - 3:30 p.m., Guests meet at the Lyon Square entrance at 9:45 a.m.*

We begin with a one-hour guided tour of Grand Rapids, passing the Gerald R. Ford Presidential Museum, learning about President Ford. Along the way we will see the Heritage Hill mansions that were built in the late 1800's and early 1900's for the movers and shakers who developed Grand Rapids. The first stop is the new Downtown Market, an urban market filled with food vendors and local products. Afterwards, we will drive to world famous Frederik Meijer Gardens and Sculpture Park; ranked in the top 100 most-visited art museums worldwide. The sculpture program features more than 200 works in the permanent collection sited both indoors and outdoors on the 158-acre main campus; integrating striking gardens with fine art. Enjoy the Lena Meijer Tropical Conservatory, English Perennial and Bulb Garden, Carnivorous Plant House, Children's Garden, and the newly opened Japanese Gardens. You can discover the outdoor park by tram and enjoy a guided 50-minute tour of the grounds included in the tour. Lunch will be provided to each guest in the Garden's restaurant.

Student Affairs Luncheon: *Monday, July 18, 11:40 p.m. to 1:00 p.m., Emerald A*
All students registered for the meeting are invited to attend. This luncheon, provided by our sponsors, is a great opportunity to meet other students, interact with the APMS leadership, and learn how to become more involved in the Society. Chis Mudge, Student Affairs Committee Chair, will be the moderator. Please contact Chris by noon Sunday, July 17 to confirm your attendance.

Regional Chapters Presidents' Luncheon: *Monday, July 18, 11:40 p.m. to 1:00 p.m., Emerald B*
Two representatives from each APMS regional chapter are invited to attend the Regional Chapter Presidents' Luncheon, provided by APMS sponsors. John Rodgers, APMS Vice President and Regional Chapters Committee Chair, will be the moderator for discussions on aquatic plant management activities in each region. Please contact John by noon Sunday, July 17, to confirm your attendance.

Annual Business Meeting: *Monday, July 18, 5:00 p.m. to 5:30 p.m., Ambassador Ballroom West*
All APMS members are encouraged to attend the APMS Annual Business Meeting for Society updates as well as electing new Officers and Directors.

Poster Session Reception: *Monday, July 18, 6:00 p.m. to 7:30 p.m., Crown Foyer - Ambassador Ballroom East*
This reception provides for the viewing of posters and exhibits along with professional interactions and discussions in a casual setting while enjoying light hors d'oeuvres and beverages. The Poster Session Reception is open to all registered delegates, guests, and students. Non-registered guests may purchase tickets for this event at the meeting registration desk.

Past Presidents' Luncheon: *Tuesday, July 19, 11:40 p.m. to 1:00 p.m., Vandenberg A*
All APMS Past Presidents are invited to attend the Past Presidents' Luncheon. Cody Gray, Immediate Past President, will be the moderator. Please contact Cody by noon Monday, July 18 to confirm your attendance.

Women in Aquatics Luncheon: *Tuesday, July 19, 11:40 p.m. to 1:00 p.m., Vandenberg B*
Amy Kay will host the APMS Women in Aquatics Luncheon, provided by APMS sponsors, to discuss issues and opportunities for women in the field of aquatic plant management. Please contact Amy by noon Monday to confirm your attendance.

Awards Reception / Banquet: *Tuesday, July 19, 6:00 p.m. to 10:00 p.m., Center Concourse / Pantlind Ballroom*
Registered delegates, guests and students are invited to the Awards Banquet in the Pantlind Ballroom. Join us in the Center Concourse outside the Pantlind Ballroom, for a pre-banquet reception from 6:00 -7:00 p.m. After dinner, we will recognize those who have served APMS, welcome new officers and directors, and this year's student paper and poster award participants. Our evening will conclude with a raffle for several prizes. Raffle tickets may be purchased at the registration desk and during the Awards Banquet. Ticket sales promote APMS sponsorship of student initiatives.

Student Tour: *Wednesday, July 20 12:30 p.m. to Thursday July 21, 4:00 p.m. Meet at Amway Grand Plaza Lobby*
All students are invited to participate in a two-day aquatic tour following the conference on Wednesday July 20 and Thursday July 21. On Wednesday, students will tour the facilities at Grand Valley State University's Annis Water Resources Institute (AWRI) in Muskegon, MI. The AWRI is a multidisciplinary institute that conducts research on ecosystem structure and function, contaminants and toxicology, hydrology, wetland ecology, limnology, and other exciting topics. After the AWRI tour, students will take a short trip over to Hoffmaster State Park to learn about dune ecology and hike the trails. We will then return to the Amway Grand Plaza Hotel for the night. On Thursday, area lakes will be toured by boat to observe active aquatic plant management projects. Our two-day tour will cover management of a variety of species, including Eurasian watermilfoil, starry stonewort, phragmites, and other invasive species. We thank our tour hosts and look forward to touring beautiful Michigan!

Events-at-a-Glance

Sunday:

APMS Board of Directors Meeting
Exhibits Setup
Poster Setup
Registration
Student Meet and Greet
Presidents' Reception

Monday:

General Meeting Opens
Guest Tour
Student Affairs Luncheon
Regional Chapters Presidents' Luncheon
APMS Annual Business Meeting
Poster Session & Reception

Tuesday:

General Session – Student Presentations
APMS Past Presidents' Luncheon
Women in Aquatics Luncheon
Awards Reception
Awards Banquet – APMS Awards Presentations

Wednesday:

General Session – Updates
General Meeting Adjourns – 12:35 p.m.
Student Tour
APMS Board of Directors Meeting

Agenda

Sunday, July 17

Sunday's Agenda-at-a-Glance

7:30 am	-	5:00 pm	APMS Board of Directors Meeting *(Pearl Room)*
12:00 pm	-	5:00 pm	Exhibits Setup *(Ambassador Ballroom East)*
12:00 pm	-	5:00 pm	Poster Setup *(Ambassador Ballroom East)*
1:00 pm	-	5:00 pm	Registration *(Crown Foyer – Ambassador Ballrooms)*
6:00 pm	-	7:00 pm	Student Meet and Greet *(Garden Court – Lobby Level)*
7:00 pm	-	9:00 pm	President's Reception *(Gerald R. and Betty Ford Presidential Ballroom)*

Monday, July 18

Monday's Agenda-at-a-Glance

7:00 am	-	8:00 am	Continental Breakfast *(Ambassador Ballroom East)*
7:00 am	-	5:00 pm	Exhibits Open (*Ambassador Ballroom East)*
7:00 am	-	5:00 pm	Posters Open *(Ambassador Ballroom East)*
7:30 am	-	5:00 pm	Registration *(Crown Foyer – Ambassador Ballrooms)*
8:00 am	-	11:40 am	Session I – Keynote Session *(Ambassador Ballroom West)*
10:00 am	-	3:30 pm	Guest Tour – Pre-registered Guests meet at the Lyon Square entrance at 9:45 am
9:40 am	-	10:00 am	Refreshment Break *(Ambassador Ballroom East)*
11:40 am	-	1:00 pm	Lunch on your own
11:40 am	-	1:00 pm	APMS Student Affairs Luncheon *(Emerald A)*
11:40 am	-	1:00 pm	Regional Chapters Presidents' Luncheon *(Emerald B)*
1:00 pm	-	5:00 pm	Session II – Midwest Session and Student Presentations *(Ambassador Ballroom West)*
2:40 pm	-	3:00 pm	Refreshment Break *(Ambassador Ballroom East)*
5:00 pm	-	5:30 pm	APMS Annual Business Meeting *(Ambassador Ballroom West)*
6:00 pm	-	7:30 pm	Poster Session and Reception *(Crown Foyer - Ambassador Ballroom East)*

Session I – Symposium and General Presentations on Midwest Aquatic Plant Management Issues

8:00 am - 11:40 am
Ambassador Ballroom West

Moderator: Dr. John Madsen - APMS President Elect, Program Committee Chair, Legislative Committee Chair
U.S. Department of Agriculture, Agriculture Research Service, Exotic and Invasive Weeds Research Unit, Davis, CA

8:00 am **Call to Order - Announcements**
John Madsen
U.S. Department of Agriculture, Agriculture Research Service, Exotic and Invasive Weeds Research Unit, Davis, CA

8:05 am **Presidential Address**
Robert J. Richardson
North Carolina State University, Crop Science Department, Raleigh, NC

8:15 am **Partnerships for Management: Practitioners, Regulators, Researchers, and Resource Managers Symposium Introduction – John Madsen**
U.S. Department of Agriculture, Agriculture Research Service, Exotic and Invasive Weeds Research Unit, Davis, CA

8:20 am **Minnesota's Approach to Management of Invasive Aquatic Plants**
Chip Welling
Minnesota Department of Natural Resources, Division of Ecological and Water Resources, Saint Paul, MN

8:40 am **Collaborative Research on Invasive Aquatic Plant Management, a Consultant's Perspective**
Paul J. Hausler
Progressive AE, Grand Rapids, MI

9:00 am **Aquatic Plant Management as a Collaborative Process from the Perspective of a Management Practitioner**
Jason Broekstra
PLM Lake & Land Management Corporation, Alto, MI

9:20 am **Collaboration for Invasive Aquatic Plant Management, A Lakeshore Owner's Perspective**
Scott Brown
Michigan Lake & Stream Association, Grass Lake, MI

9:40 am **Refreshment Break** *(Ambassador Ballroom East)*

10:00 am **Role of Government Research on Regional Aquatic Plant Management Issues: Demonstration Projects**
Michael D. Netherland[1] and Kurt D. Getsinger[2]
[1]*U.S. Army Engineer and Research Development Center, Environmental Laboratory, Gainesville, FL*
[2]*U.S. Army Engineer and Research Development Center, Environmental Laboratory, Vicksburg, MS*

10:20 am **The Role of a University Specialist in Regional Aquatic Plant Management Programs**
Robert J. Richardson and Steve T. Hoyle
North Carolina State University, Crop Science Department, Raleigh, NC

10:40 am **Panel Discussion**

11:00 am **The Michigan Aquatic Nuisance Plant Species Program**
Lisa Huberty
Michigan Department of Environmental Quality, Water Resources, Division, Lansing, MI

11:20 am **Michigan's Aquatic Invasive Species Program – Five Years of Enhancements**
Sarah LeSage
Michigan Department of Environmental Quality, Water Resources Division, Lansing, MI

11:40 am **Morning Wrap-up and Announcements - Lunch on your own**

Session II – Midwest Session and Student Presentations

1:00 pm - 5:00 pm
Ambassador Ballroom West

Moderator: Michael D. Netherland, APMS Awards Committee Chair, Past President (2014)
U.S. Army Engineer and Research Development Center, Environmental Laboratory, Gainesville, FL

1:00 pm **Response of Aquatic Macrophytes to Removal of Invasive Common Carp in a Minnesota Shallow Lake *(Student Presentation)***
Melaney Dunne[1], Raymond M. Newman[1], Przemyslaw G. Bajer[2], and Peter Sorensen[1]
[1]*University of Minnesota, Department of Fisheries, Wildlife, and Conservation Biology, Saint Paul, MN*
[2]*University of Minnesota, Minnesota Aquatic Invasive Species Research Center, Saint Paul, MN*

1:20 pm **Water Soldier (*Stratiotes aloides*) in Ontario - Preventing Its Spread to the Great Lakes**
Holly I. Simpson
Ontario Ministry of Natural Resources and Forestry, Peterborough, Ontario, Canada

1:40 pm **Response of Eurasian and Hybrid Watermilfoil to Five Auxin-mimic Herbicides *(Student Presentation)***
Jens Beets[1] and Michael D. Netherland[2]
[1]*University of Florida, Agronomy Department, Gainesville, FL*
[2]*U.S. Army Engineer and Research Development Center, Environmental Laboratory, Gainesville, FL*

2:00 pm **Invasional Meltdown in Minnesota Lakes: Non-native Plants Are Winners and Native Plants Are Losers when Common Carp Invade**
Daniel J. Larkin[1], Marcus W. Beck[2], and Przemyslaw G. Bajer[1]
[1]*University of Minnesota, Minnesota Aquatic Invasive Species Research Center, Saint Paul, MN*
[2]*U.S. Environmental Protection Agency, National Health and Environmental Effects Research Laboratory, Gulf Breeze, FL*

2:20 pm **Biology and Management of Monoecious Hydrilla (*Hydrilla verticillata*) *(Student Presentation)***
Joshua D. Wood[1] and Michael D. Netherland[2]
[1]*University of Florida, Center for Aquatic and Invasive Plants, Gainesville, FL*
[2]*U.S. Army Engineer and Research Development Center, Environmental Laboratory, Gainesville, FL*

2:40 pm **Refreshment Break** *(Ambassador Ballroom East)*

3:00 pm **Evaluating the Sensitivity of Seven Aquatic Plants to Procellacor™ Herbicide *(Student Presentation)***
Erika Haug[1], Robert J. Richardson[1], Michael D. Netherland[2], and Mark Heilman[3]
[1]*North Carolina State University, Crop Science Department, Raleigh, NC*
[2]*U.S. Army Engineer and Research Development Center, Environmental Laboratory, Gainesville, FL*
[3]*SePRO Corporation, Carmel, IN*

3:20 pm **Hydrilla (*Hydrilla verticillata*) Risk Assessment for the Great Lakes Basin**
Carl E. Mach[1], Kris Erickson[1], Matthew A. Barnes[2], Jonathan M. Bossenbroek[3], Robert J. Richardson[4], Christina Rockwell[5], and Kathleen Evans[1]
[1]*Ecology and Environment, Incorporated., Lancaster, NY*
[2]*Texas Tech University, Natural Resources Management, Lubbock, TX*
[3]*University of Toledo, Environmental Science, Toledo, OH*
[4]*North Carolina State University, Crop Science Department, Raleigh, NC*
[5]*Ecology and Environment, Incorporated, Buffalo, NY*

3:40 pm **Potential Spread of Hydrilla (*Hydrilla verticillata*) to the Great Lakes Basin (*Student Presentation*)**
Kristen M. Hebebrand and Jonathan M. Bossenbroek
University of Toledo, Environmental Science, Toledo, OH

4:00 pm **Combining Multiple Species Distribution Modeling Approaches to Predict Suitable Habitat for the Invasive Aquatic Macrophyte *Hydrilla verticillata***
Matthew A. Barnes[1], Carl Mach[2], Carlos Portillo-Quintero[1], Christina Rockwell[2], Sasha D. Soto[1], and Kris Erickson[2]
[1]*Texas Tech University, Natural Resources Management Department, Lubbock, TX*
[2]*Ecology and Environment, Incorporated, Lancaster, NY*

4:20 pm **Competition of Select Submersed Aquatic Plants with Hydrilla in a Cool and a Warm Climate *(Student Presentation)***
Amy Henry, Tyler Harris, and Robert J. Richardson
North Carolina State University, Crop Science Department, Raleigh, NC

4:40 pm **Development and Enhancement of the Michigan Invasive Aquatic Plant Citizen Monitoring Program**
Angela A. De Palma-Dow and Jo Latimore
Michigan State University, East Lansing, MI

5:00 pm **APMS Annual Business Meeting**

6:00 pm **Poster Session and Reception** *(Crown Foyer - Ambassador Ballroom East)*

Poster Session

6:00 pm - 7:30 pm
Ambassador Ballroom East

Starry Stonewort: Using eDNA Technology to Address Identification Challenges Faced by Lake Monitoring Volunteers and Professionals
Angela A. De Palma-Dow[1], Erick Elgin[2], Maggie Williams[3], and Jo Latimore[1]
[1]Michigan State University, East Lansing, MI
[2]MiCorps Cooperative Lakes Monitoring Program, East Lansing, MI
[3]Michigan State University, Environmental Engineering, East Lansing, MI

An Evaluation of Past and Present Aeration Designs: An Ohio Case Study
Patrick M. Goodwin
Vertex Water Features, Ponte Vedra Beach, FL

Control of Dreissenid Mussels with a more Rational Use of Copper
David G. Hammond
Earth Science Labs, Incorporated, Greenbrae, CA

2,4-D Metabolism in Eurasian Watermilfoil (*Myriophyllum spicatum*) and Several 2,4-D Tolerant Milfoil Hybrid Populations (*M. spicatum* X *M. sibiricum*) *(Student Presentation)*
Kallie C. Kessler, Mirella Ortiz, and Scott J. Nissen
Colorado State University, Fort Collins, CO

Delta Region Areawide Aquatic Weed Project and the Adaptive Management of Invasive Weeds in the Sacramento / San Joaquin River System
John D. Madsen[1], Patrick J. Moran[2], Paul J. Pratt[2], David L. Bubenheim[3], and Edward J. Hard[4]
[1]U.S. Department of Agriculture, Agriculture Research Service, Exotic and Invasive Weeds Research Unit, Davis, CA
[2]U.S. Department of Agriculture, Agriculture Research Service, Exotic and Invasive Weeds Research Unit, Albany, CA
[3]National Aeronautics and Space Administration, Ames Research Center, Moffett Field, CA
[4]California Department of Parks and Recreation, Division of Boating and Waterways, Sacramento, CA

Integration of Prevention, Early Detection, and Suppression of Aquatic Invasive Species: An Example from Eurasian Watermilfoil Management
Alejandro Reyes
State University of New York, Oneonta Biological Field Station, Oneonta, NY

Ecological Restoration Using Aquatic Mechanical Harvesting
Bruce A. Richards
Weedoo Shoreline Workboats, Incorporated, Hockessin, DE

Incorporation of Biotype Alters Species Distribution Model Predictions of Suitable Habitat for the Invasive Aquatic Macrophyte, *Hydrilla verticillata (Student Presentation)*
Sasha D. Soto[1], Carl Mach[2], Carlos Portillo-Quintero[1], Christina Rockwell[2], Kris Erickson[2], and Matthew A. Barnes[1]
[1]Texas Tech University, Natural Resources Management Department, Lubbock, TX
[2]Ecology and Environment, Incorporated, Lancaster, NY

The Effects of the Contact Herbicide Diquat on Mixed Stands of Flowering Rush and Hardstem Bulrush in Lake Sallie, MN - a Pilot Study
Lee G. Turnage[1], Brent Alcott[2], and Tera Guetter[2]
[1]Mississippi State University, Geosystems Research Institute, Starkville, MS
[2]Pelican River Watershed District, Detroit Lakes, MN

Tuesday, July 19

Tuesday's Agenda-at-a-Glance

7:00 am	-	8:00 am	Continental Breakfast *(Ambassador Ballroom East)*
7:00 am	-	5:20 pm	Exhibits Open *(Ambassador Ballroom East)*
7:00 am	-	5:20 pm	Posters Open *(Ambassador Ballroom East)*
7:30 am	-	5:00 pm	Registration *(Crown Foyer – Ambassador Ballroom)*
8:00 am	-	11:40 am	Session III – General Session and Student Presentations *(Ambassador Ballroom West)*
9:40 am	-	10:00 am	Refreshment Break *(Ambassador Ballroom East)*
11:40 am	-	1:00 pm	Lunch on your own
11:40 am	-	1:00 pm	APMS Past Presidents' Luncheon *(Vandenberg A)*
11:40 am	-	1:00 pm	Women in Aquatics Luncheon *(Vandenberg B)*
1:00 pm	-	5:20 pm	Session IV – General Session and Student Presentations *(Ambassador Ballroom West)*
2:40 pm	-	3:00 pm	Refreshment Break *(Ambassador Ballroom East)*
6:00 pm	-	7:00 pm	Awards Reception *(Center Concourse)*
7:00 pm	-	10:00 pm	Awards Banquet *(Pantlind Ballroom)*
8:30 pm	-	10:00 pm	APMS Awards Presentations *(Pantlind Ballroom)*

Session III – General Session and Student Presentations

8:00 am - 11:40 am
Ambassador Ballroom West

Moderator: Christopher R. Mudge – APMS Student Affairs Committee Chair
U.S. Army Corps of Engineers, Engineer Research and Development Center, Baton Rouge, LA

8:00 am **Absorption Rates of 2,4-D Butoxyethyl Ester and 2,4-D Amine by Eurasian Watermilfoil *(Student Presentation)***
Mirella Ortiz[1], Kallie Kessler[1], Scott J. Nissen[1], Ryan Wersal[2] and William Ratajczyk[3]
[1]Department of Bioagricultural Sciences and Pest Management, Colorado State University, Fort Collins, CO
[2]Lonza, Alpharetta, GA
[3]Lonza, Reedsburg, WI

8:20 am **AERF Update**
Carlton Layne
Aquatic Ecosystem Restoration Foundation, Marietta, GA

8:40 pm **Identifying Morphological Differences and Herbicide Efficacy of the Uruguay Water Primrose Complex (*Ludwigia uruguayensis*) in Florida *(Student Presentation)***
Afsari Banu, Stephen F. Enloe, and Colette Jacono
University of Florida, Agronomy Department, Gainesville, FL

9:00 am **At the Front of a Storm: What Emerging Federal Processes for Endangered Species Risk Assessment Will Mean to the Registration**
Bernalyn D. McGaughey
Compliance Services International, Lakewood, WA

9:20 am **A Novel High-throughput Genotyping Assay for Distinguishing *Myriophyllum* spp. and their Hybrids *(Student Presentation)***
Kallie C. Kessler[1], Eric L. Patterson[1], Margaret B. Fleming[2], Scott J. Nissen[1], and Todd A. Gaines[1]
[1]Colorado State University, Fort Collins, CO
[2]U.S. Department of Agriculture, Agriculture Research Service, National Center for Genetic Resources Preservation, Fort Collins, CO

9:40 am **Refreshment Break** *(Ambassador Ballroom East)*

10:00 am **Effects of Aquatic Herbicides on Brazilian Pepper Tree (*Schinus terebinthifolius*) *(Student Presentation)***
Cody A. Lastinger and Stephen F. Enloe
University of Florida, Agronomy Department, Gainesville, FL

10:20 am **Washington Update**
Lee VanWychen
Weed Science Society of America, Alexandria, VA

10:40 am **Influence of Copper Algaecide Concentration and Formulation on Aqueous Microcystin-LR Degradation *(Student Presentation)***
Kyla J. Iwinski[1], Ciera M. Kinley[2], Alyssa Calomeni[2], Tyler Geer[2], and John Rodgers, Jr.[2]
[1]Clemson University, Department of Wildlife and Fisheries Biology, Clemson, SC
[2]Clemson University, Department of Forestry and Environmental Conservation, Clemson, SC

11:00 am **Control of Taste and Odor Producing Algae in Source Water for Anderson Regional Joint Water System**
John H. Rodgers, Jr.[1], Alyssa Calomeni[1], Kyla J. Iwinski[2], Tyler Geer[1], Matt Huddleston[3], Scott Willett[4], Jennifer Barrington[4]
[1]Clemson University, Department of Forestry and Environmental Conservation, Clemson, SC
[2]Clemson University, Department of Wildlife and Fisheries Biology, Clemson, SC
[3]SynTerra, Greenville, SC
[4]Anderson Regional Joint Water System, Anderson, SC

11:20 am **Influence of Dissolved and Particulate Organic Carbon on Exposures of an SCP Algaecide and Consequent Responses of *Microcystis aeruginosa (Student Presentation)***
Tyler Geer, Ciera M. Kinley, Kyla J. Iwinski, Alyssa Calomeni, John H. Rodgers, Jr.
Clemson University, Department of Forestry and Environmental Conservation, Clemson, SC

11:40 am **Morning Wrap-up and Announcements - Lunch on your own**

Session IV – General Session and Student Presentations

1:30 pm - 5:00 pm
Ambassador Ballroom West

Moderator: Ryan M. Wersal – APMS Director
Lonza, Alpharetta, GA

1:00 pm **Field Monitoring and Sampling of Chemically Treated Giant Salvinia in Louisiana and Texas**
Christopher R. Mudge[1] and Bradley T. Sartain[2]
[1]U.S. Army Engineer and Research Development Center, Baton Rouge, LA
[2]Louisiana State University, School of Plant, Environmental, and Soil Sciences, Baton Rouge, LA

1:20 pm **Bald Cypress (*Taxodium distichum* (L.) Rich.) Survival and Re-leafing Success in Response to Low GPA Winter Herbicide Applications for Managing Giant Salvinia (*Salvinia molesta* D.S. Mitchell) *(Student Presentation)***
Bradley T. Sartain[1] and Christopher R. Mudge[2]
[1]Louisiana State University, School of Plant, Environmental, and Soil Sciences, Baton Rouge, LA
[2]U.S. Army Engineer and Research Development Center, Baton Rouge, LA

1:40 pm **The Corps of Engineers Aquatic Plant Control Research Program – An Update**
Linda Nelson[1] and Jeremy Crossland[2]
[1]U.S. Army Engineer Research and Development Center, Vicksburg, MS
[2]U.S. Army Corps of Engineers, Headquarters, Washington, DC

2:00 pm **Evaluation of an Integrated Pest Management Approach using Herbicide Treatments and the Giant Salvinia Weevil (*Cyrtobagous salviniae*) to Control Giant Salvinia (*Salvinia molesta*) *(Student Presentation)***
Allie Cozad[1] and Christopher R. Mudge[2]
[1]*Louisiana State University, Natchitoches, LA*
[2]*U.S. Army Engineer and Research Development Center, Baton Rouge, LA*

2:20 pm **The State of the State of Old World Climbing Fern in Florida**
Stephen F. Enloe
University of Florida, Agronomy Department, Gainesville, FL

2:40 pm **Refreshment Break** *(Ambassador Ballroom East)*

3:00 pm **Monoecious Hydrilla Management in a Lotic System: Target and Non-target Responses to Fluridone *(Student Presentation)***
Shannon Auell[1], Greg Cope[2], Steve T. Hoyle[1], and Robert J. Richardson[1]
[1]*North Carolina State University, Crop Science Department, Raleigh, NC*
[2]*North Carolina State University, Applied Ecology Department, Raleigh, NC*

3:20 pm **The Challenges and Techniques of Managing Monoecious Hydrilla in Flowing Water Systems**
Justin J. Nawrocki and Robert J. Richardson
North Carolina State University, Crop Science Department, Raleigh, NC

3:40 pm **Integrated Management of Waterhyacinth (*Eichhornia crassipes*) *(Student Presentation)***
Samantha Sardes[1], Lyn A. Gettys[1], Carl J. Della Torre III[1], Carey Minteer[2], and Philip Tipping[2]
[1]*University of Florida, Ft Lauderdale Research and Education Center, Davie, FL*
[2]*U.S. Department of Agriculture, Agriculture Research Service, Invasive Plants Research Laboratory, Davie, FL*

4:00 pm **Monitoring and Research Advancements of Invasive Milfoil Control**
Eddie J. Heath[1], Michelle Nault[2], John Skogerboe[3], and Tim Hoyman[1]
[1]*Onterra LLC, De Pere, WI*
[2]*Wisconsin Department of Natural Resources, Green Bay, WI*
[3]*Retired - U.S. Army Corps of Engineers, Engineer Research and Development Center, Lake Elmo, MN*

4:20 pm **Correlation of Hydroacoustic Biovolume Estimation to Submersed Plant Biomass *(Student Presentation)***
Andrew Howell and Robert J. Richardson
North Carolina State University, Crop Science Department, Raleigh, NC

4:40 pm **Factors Affecting Curlyleaf Pondweed Frequency of Occurrence and Relative Density in Managed and Unmanaged Systems: An Analysis of Results from 60 Lakes**
Raymond M. Newman and Adam R. Kautza
University of Minnesota, Department of Fisheries, Wildlife, and Conservation Biology, Saint Paul, MN

5:00 pm **The Effects of Organic Matter Content, Nitrogen, and Phosphorus on Growth of Illinois Pondweed *(Student Presentation)***
Jonathan R. Gosselin and William Haller
University of Florida, Agronomy Department, Center for Aquatic and Invasive Plants, Gainesville, FL

5:20 pm **Adjourn General Session**

6:00 pm **Awards Reception** *(Center Concourse)*
7:00 pm **Awards Banquet** *(Pantlind Ballroom)*

Wednesday, July 20

Wednesday's Agenda-at-a-Glance

7:00 am	-	8:00 am	Continental Breakfast *(Ambassador Ballroom East)*
7:00 am	-	10:00 am	Exhibits Open *(Ambassador Ballroom East)*
7:00 am	-	10:00 am	Posters Open *(Ambassador Ballroom East)*
7:30 am	-	12:00 pm	Registration *(Crown Foyer – Ambassador Ballroom)*
8:00 am	-	12:35 pm	Session V – General Presentations and Updates *(Ambassador Ballroom West)*
9:40 am	-	10:00 am	Refreshment Break *(Ambassador Ballroom East)*
10:00 am	-	12:00 pm	Poster and Exhibit Breakdown *(Ambassador Ballroom East)*
12:45 pm	-		Student Tour Begins
1:15 pm	-	5:00 pm	APMS Board of Directors Meeting (*Grandview Room)*

Session V – General Presentations and Updates

8:00 am - 12:30 pm
Ambassador Ballroom West

Moderator: Dr. John H. Rodgers, Jr. - APMS Vice President, Regional Chapters Committee Chair
Clemson University, Department of Forestry and Environmental Conservation, Clemson, SC

8:00 am **PROCELLACOR™ – A Novel Herbicide Technology in Development for Aquatic Plant Management**
Mark A. Heilman
SePRO Corporation, Carmel, IN

8:20 am **Mesocosm Evaluations on Hybrid Milfoil from Three Wisconsin Lakes**
Ryan M. Wersal[1], Scott M. Provost[2], Brenda Nordin[3], and Bill Ratajzcyk[4]
[1]Lonza, Alpharetta, GA
[2]Wisconsin Department of Natural Resources, Wisconsin Rapids, WI
[3]Wisconsin Department of Natural Resources, Green Bay, WI
[4]Lonza, Jackson, WI

8:40 am **Vegetative Reproductive Ability of Crested Floating Heart (*Nymphoides cristata*)**
Lyn A. Gettys, Carl J. Della Torre III, and Kyle Thayer
University of Florida, Fort Lauderdale Research and Education Center, Davie, FL

9:00 am **Strategic Management of Aquatic Weeds in New Zealand**
Paul D. Champion
National Institute of Water and Atmospheric Research, Hamilton, New Zealand

9:20 am **Eradicating Aquatic Weeds - Success and Progress**
Deborah E. Hofstra[1], John S. Clayton[2], and Paul D. Champion[2]
[1]National Institute of Water and Atmospheric Research, Freshwater and Estuaries Centre, Hamilton, New Zealand
[2]National Institute of Water and Atmospheric Research, Hamilton, New Zealand

9:40 am **Refreshment Break** *(Ambassador Ballroom East)*

10:00 am **Evaluation of EcoAnalytics and Canopeo: Tools to Assist with Aquatic Plant Surveys and Impacts of Herbicide Treatments**
Dean Jones[1], Ryan Moore[2], and Michael D. Netherland[3]
[1]University of Florida, Center for Aquatic and Invasive Plants, Lake Alfred, FL
[2]Gator Creek Technologies, LLC, Lakeland, FL
[3]U.S. Army Engineer and Research Development Center, Environmental Laboratory, Gainesville, FL

10:20 am **Total Lake Vegetation Mapping Utilizing Sonar Plus Other Sensing Technologies**
Steve T. Hoyle, Andrew Howell, and Robert J. Richardson
North Carolina State University, Crop Science Department, Raleigh, NC

10:40 am **Data Deluge from Automated Sensors: A Problem for Aquatic Plant Management or an Opportunity?**
Ray D. Valley
Navico (BioBase), Digital Marine Division, Minneapolis, MN

11:00 am **The Potential for Cryptic Taxa in Aquatic Systems**
Syndell Parks
GenPass LLC, Muskegon, MI

11:20 am **Effective Management of Starry Stonewort**
Ben E. Willis and West M. Bishop
SePRO, SePRO Research & Technology Campus, Whitakers, NC

11:40 am **Sediment and Nutrient Reduction Using Bacteria**
Clarence E. Timmer[1] and Trace Wolfe[2]
[1]*Aquatic Vegetation Control, Incorporated, Port Saint Lucy, FL*
[2]*Clear Waters, Incorporated, New Smyrna Beach, FL*

12:00 pm **APMS Regional Chapters: An Update on Key Initiatives within Each Region**

Western	South Carolina	Midwest	Florida
Texas	Northeast	MidSouth	

12:35 pm **Wrap-up and Adjourn 56th Annual Meeting**

1:15 pm **APMS Board of Directors Meeting** *(Grandview Room)*

57th Annual Meeting
Hilton Daytona Beach Resort
Ocean Walk Village
Daytona Beach, Florida
July 16-19, 2017

58th Annual Meeting
Hyatt Regency Buffalo
Buffalo, New York
July 15-18, 2018

59th Annual Meeting
Doubletree San Diego Mission Valley
San Diego, California
July 14-17, 2019

Abstracts - General Sessions and Poster Session

Abstracts are listed alphabetically by presenting author - appears in **bold.**

Monoecious Hydrilla Management in a Lotic System: Target and Non-target Responses to Fluridone *(Student Presentation)*

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Hydrilla (*Hydrilla verticillata*) is an invasive aquatic weed that has been spreading throughout North Carolina's lakes and reservoirs since it was first discovered in 1980. It is now invading increasingly dynamic and high biodiversity systems such as rivers and natural lakes. One recent site of invasion is the Eno River system in the Piedmont region of the state. The Eno is a tributary of the Neuse River, and is home to several rare species including the panhandle pebblesnail (*Somatogyrus virginicus*). It is also a significant source of water for Falls Lake, the drinking water reservoir for the City of Raleigh, NC and several surrounding areas. In 2015, an aquatic herbicide treatment with fluridone (Sonar Genesis) was conducted in the Eno River, marking the first metered herbicide treatment of hydrilla within a riverine system in the state. We evaluated the herbicide treatment impacts to selected target and non-target aquatic species. Efforts included quantitative sampling of *H. verticillata*, *S. virginicus*, and *Podostemum ceratophyllum* (native vegetation habitat of *S. virginicus*) at seven spatially separated sites along the Eno River. Biweekly vegetation monitoring and monthly snail sampling began in late May, two weeks before treatment, and continued through December. *H. verticillata* shoot lengths were significantly reduced during treatment from an average of 23.4 cm to 10.6 cm. Average density of *S. virginicus* was significantly different among sites, ranging from 5,537 snails/m^2 to 1,782.4 snails/m^2. Monthly snail density averaged among all sites differed over the course of the sampling season, with lower densities found in October and December. Average monthly snail densities during treatment months did not differ significantly. *P. ceratophyllum* densities differed between treated and untreated sites with means of 13,736 and 10,682 stems/m^2, respectively. Overall, fluridone effectively reduced hydrilla density within the treated area with no apparent negative impact to the studied non-target species.

Identifying Morphological Differences and Herbicide Efficacy of the Uruguay Water Primrose Complex (*Ludwigia uruguayensis*) in Florida (*Student Presentation*)

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The Uruguay water primrose complex (Ludwigia uruguayensis), hereafter referred to as L. uruguayensis, has become one of the biggest threats to many Florida lakes over the last five years. Its rapid spread, coupled with variable herbicidal control has greatly concerned many lake managers. Furthermore, variable morphology has been observed between populations and few studies have investigated this issue. The objectives of the study were to identify morphological differences, growth patterns and response to herbicides between L. uruguayensis populations collected across Florida. Plants were collected from five different lakes in Florida and grown in stock tanks. For morphological (vegetative and floral) data collection, stem cuttings from each lake population were planted and maintained in 900 L mesocosms, each replicated four times. Morphological data collected included total stem length, stem thickness, internode length, total number of shoots (retained and abscised), leaf shape, petiole length, petal length and width, sepal length, petal margin, style length, length of long and short filaments, ovary length, pedicel length, and diameter of pollen grains. Morphological data was analyzed using cluster analysis. For herbicide screening, stem cuttings from each population were planted in 3 L pots and grown under greenhouse conditions. One month old plants were treated with four different aquatic herbicides each at seven different doses with four replicate pots per treatment. Preliminary results indicate strong differences between populations for the morphological parameters sampled. Additionally, we found significant differences in population response to herbicide treatment. These results suggest a high degree of complexity in L. uruguayensis management and further study is needed to refine management approaches.

Combining Multiple Species Distribution Modeling Approaches to Predict Suitable Habitat for the Invasive Aquatic Macrophyte *Hydrilla verticillata*

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Species distribution models (SDMs) aid in the prediction of potential species ranges by developing an understanding of current species distributions and their relationships to underlying environmental data. Such predictions are useful for a variety of conservation applications, including risk assessment for invasive species. Due to this wide utility, multiple SDM methodologies have been developed. We have compared two SDM methods, the popular Maxent approach and the more recently developed MaxLike method, to predict suitable habitat for the invasive aquatic macrophyte hydrilla (*Hydrilla verticillata*). Focusing on risk assessment in the U.S. as a case study, both models predicted wide invasive potential (i.e. distribution of suitable habitat) for hydrilla, including much of the southern U.S. from Florida to California and northward along both coasts to Oregon in the west and New England in the east. Notably, large portions of the lower Great Lakes also appear to include suitable hydrilla habitat. Specific predictions varied between modeling approaches, however, and we highlight regions of strongest agreement and discrepancy between the two approaches. The results of this work will contribute to a larger risk assessment for hydrilla in the Great Lakes basin and help prioritize management/control efforts. This multiple-SDM approach can aid invasive species management by identifying regions of relative confidence and uncertainty.

Response of Eurasian and Hybrid Watermilfoil to Five Auxin-mimic Herbicides *(Student Presentation)*

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The newly developed arylpicolinate herbicide SX-1552 (Procellacor™) has shown promise on several problematic aquatic weeds including Eurasian Watermilfoil (*Myriophyllum spicatum:* EWM). While EWM is sensitive to auxin herbicides, effects on some hybrid populations, (*M. spicatum* x *M. sibiricum*) indicate a reduced response to 2,4-D. The objective of this study was to compare the response of EWM to a hybrid genotype from Hayden Lake, Idaho using a small-scale laboratory assay. We compared the activity of five different auxin compounds: SX-1552, triclopyr, 2,4-D, aminopyralid, and aminocyclopyrachlor within and between milfoil genotypes. To effectively address these questions we used growth chambers to incubate plants for 17 DAT. Both genotypes were grown under an OECD protocol developed for evaluating herbicide activity on an aquatic dicot (i.e. EWM) in Europe. Plants were treated at concentrations ranging from 0.1 to 729 µg/L and exposures were static. Dry weight biomass data were subjected to non-linear regression and EC_{50} values were determined for quantitative comparison between the herbicides and genotypes. EWM was more sensitive to all five auxin herbicides when compared to the hybrid. EC_{50} values for hybrid watermilfoils were ~3 to 18 times greater than those calculated for EWM. SX1552 was the most active auxin with EC_{50} values 40 to 409 times lower on EWM and 24 to 109 times lower on the hybrid genotype. The comparatively low activity of aminopyralid and aminocyclopyrachlor was not expected given the high levels of activity of these compounds at low use rates in terrestrial systems, but data were consistent across watermilfoil genotypes and studies. Results from this work suggest this hybrid genotype is more tolerant to all five auxin-mimic herbicides. A proposed mechanism for this enhanced tolerance remains under study. These results also suggest this protocol may be useful in evaluating herbicide tolerance of hybrid watermilfoils.

Aquatic Plant Management as a Collaborative Process from the Perspective of a Management Practitioner

Jason Broekstra

PLM Lake & Land Management Corp, Alto, MI

Collaboration for Invasive Aquatic Plant Management, A Lakeshore Owner's Perspective

Scott Brown

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Strategic Management of Aquatic Weeds in New Zealand

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The isolation of New Zealand compared to other land masses, being over 1,500 km from the nearest neighbouring country, buffer it from the introduction of pests and diseases. This is beneficial, and the management of entry pathways through air and sea ports and a single international mail centre protect both our natural heritage and permit an economy largely based on primary production without many of the biosecurity threats experienced in other countries. New Zealand's border management is rightly heralded as a world leader in the field of biosecurity. Despite this, a large number of pests, including over 50 aquatic weeds have already crossed the national border and threaten freshwater resources. This paper discusses national and regional legislation and management relating to aquatic weeds once they are found within the country, including assessment and control of new weed threats, prevention and mitigation of subsequent deliberate or accidental spread, and integration of proactive aquatic weed management into a regional lake management strategy. Several biosecurity measures have been initiated that effectively mitigate the impacts of a number of our worst weeds. These include a national ban on propagation, sale and distribution, and national and regional government-run programs to manage naturalized high-risk weeds. A program has been developed and instigated in the northernmost region of the North Island of New Zealand in order to protect nationally important sand dune lakes. Management actions include eutrophication protection measures alongside biosecurity actions that include prioritizing the risk of weed spread, management initiatives at lake entry points, surveillance (early detection monitoring) and incursion response. Additionally, weed infestations have been strategically managed in some waterbodies where they threaten adjacent unimpacted lakes.

Evaluation of an Integrated Pest Management Approach using Herbicide Treatments and the Giant Salvinia Weevil (*Cyrtobagous salviniae*) to Control Giant Salvinia (*Salvinia molesta*) *(Student Presentation)*

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Giant salvinia (*Salvinia molesta*), an invasive aquatic fern, is problematic in Louisiana, Texas, and surrounding states. Since its introduction in 1999, natural resource agencies in Louisiana and Texas are finding new infestations on an annual basis. Aquatic plant managers primarily relied on herbicides to combat giant salvinia until the recent expansion of the biological control agent, giant salvinia weevil (*Cyrtobagous salvinia*). During the past decade, the tank mix of glyphosate, diquat, and two surfactants has been utilized to control giant salvinia during the growing season. Annual weevil releases are necessary to re-infest sites due to winter insect mortality. There has been limited research to investigate an integrated pest management (IPM) approach using chemical and biological control technologies to manage giant salvinia. Therefore, mesocosm trials were conducted in 2015 and 2016 to evaluate herbicide and weevil efficacy in an IPM approach. The 12-week study evaluated weevils, flumioxazin, penoxsulam, and glyphosate plus diquat. All herbicides or weevils were applied alone or in combination and all treatments involving herbicides included a surfactant. A non-treated control was also included. In 2015, all treatments decreased giant salvinia coverage and fresh weight biomass at 6 weeks after treatment (WAT); however only two treatments (penoxsulam and penoxsulam plus weevils) continued to decrease biomass through 12 WAT. Weevil densities (adult and larvae per kg of fresh weight giant salvinia) in the flumioxazin plus weevil treatment remained similar from pre-treatment to 12 WAT, while weevil densities in the penoxsulam plus weevil treatments were reduced 100% by the conclusion of the trial. Conversely, weevil densities in the glyphosate plus diquat plus weevil and weevil only treatments increased by the conclusion of the trial. Although penoxsulam plus weevil reduced plant biomass more than any other treatment, there were no surviving weevils at 12 WAT; therefore, this particular herbicide is not a viable option for maintaining weevils. Based on 2015 research, the most viable IPM option through 12 WAT is flumioxazin plus weevils due to the reduction in plant coverage, fresh weight biomass reduction and high weevil density.

Development and Enhancement of the Michigan Invasive Aquatic Plant Citizen Monitoring Program
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The Exotic Aquatic Plant Watch (EAPW) is a specialized volunteer component of Michigan's Cooperative Lakes Monitoring Program. This citizen science program connects the public to their local aquatic resources and provides valuable aquatic invasive species data to local and state managers. Although public interest in the EAPW is great, evidenced by high attendance at annual training sessions, volunteer enrollment and completion rates were initially quite low. To address these concerns, we gathered volunteer feedback via surveys and visited volunteers on 31 lakes during 2013-2015 to identify barriers to enrollment and reporting and learned how program staff could improve volunteer participation and experience. Surveys revealed that the most common reason for not enrolling was the belief that monitoring was unnecessary if a professional plant management contractor had been hired for the lake and that many enrolled volunteers were failing to report negative results (e.g., reporting that no invasive plants were found during the volunteer survey). During lake visits we learned that many volunteers were unsure of how and where to sample, lacked confidence in correctly identifying plants and lacked a user-friendly Michigan-specific invasive aquatic plant resource. In response to these findings, we improved program promotion and improved the EAPW protocol and training. We also incorporated a new, Michigan-specific aquatic invasive plant field guide that is lightweight, small and water resistant. After applying these strategies to the program, we saw a 23% increase in lake enrollment and reporting rates almost doubled from 43% to 79% during 2011-2015. These results indicate that hands-on staff involvement, investment in training and resources and monitoring volunteer feedback are essential to increasing participation and reporting of aquatic invasive species. We plan to continue lake visits and partnering with the state to maintain and grow this important program.

Starry Stonewort: Using eDNA Technology to Address Identification Challenges Faced by Lake Monitoring Volunteers and Professionals
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Starry Stonewort (*Nitellopsis obtusa*), a particularly troublesome and aggressive invasive aquatic macroalgae, has been found in some Michigan lakes since the 1980s. Lake associations, with the help of Citizen Lake monitors enrolled in a statewide AIS detection program, have been successful in incorporating AIS management strategies once Starry Stonewort has been accurately identified in their lake. Starry can be positively identified by locating the reproductive structures that appear as small, white starry bulbils. A problem arises when a plant is found that could most likely be Starry Stonewort or could be a native look-a-like macroalga, *Nitella* spp., but lacks the presence of any such star-shaped bulbils. There are many reasons why technicians, citizen monitors or researchers might fail to find stars on a potential Starry Stonewort plant, but in the time where even a year or two can determine if a lake is successful in initiating a rapid response management plan, the ability to quickly, easily and inexpensively provide a positive ID for an aquatic invasive is extremely necessary. Using previously developed eDNA technology produced by the Environmental Engineering laboratory at Michigan State University, and small preserved tissue fragments, we tested the efficacy of providing an accurate ID to a verified sample of Starry Stonewort versus verified samples of non-Starry Nitella and Chara. In this talk we will present our methods, results and how we incorporated this information into the AIS early detection and rapid response toolbox for citizen monitors, agency personnel, lake managers and researchers concerned about AIS in Michigan inland lakes.

Response of Aquatic Macrophytes to Removal of Invasive Common Carp in a Minnesota Shallow Lake *(Student Presentation)*
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We investigated the response of an aquatic plant community to common carp (*Cyprinus carpio*) removal in Staring Lake, a 66 ha shallow (maximum depth 4.9m) lake in the Twin Cities metropolitan area in Minnesota (U.S.). Carp

abundance was estimated using mark-recapture and macrophytes were surveyed for frequency of occurrence, relative abundance, and biomass with point intercept surveys (170 points) in spring (May or June) and summer (August). Carp were abundant in the lake before removal (490/ha, or 26,000 age 3 or older individuals) and plant frequency of occurrence in water <4.6-m deep was <15% and plant dry biomass was <2g/m^2. Eight plant species were found with invasive curlyleaf pondweed (*Potamogeton crispus*) being the most common and occurring at ≤7% of sites. Although carp removal began in 2012, significant reductions did not occur until winter 2014 when abundance was reduced to 190 kg/ha. Further carp removal occurred in 2015 decreasing the abundance to 100 kg/ha. Plants were sparse in 2012 and 2013, but increased to 29% occurrence in spring 2014 and 40% in 2015. Macrophyte biomass increased to 3 g/m^2 in 2014 and 9 g/m^2 in 2015. Curlyleaf pondweed continued to be dominant, increasing to 28% occurrence and 8 g/m^2 in 2015. Native macrophytes such Canada waterweed (*Elodea canadensis*), narrowleaf pondweed (*Potamogeton pusillus*) and sago pondweed (*Stuckinea pectinata*) also increased in occurrence and 13 species were found in summer 2015. In October 2015, Eurasian watermilfoil (*Myriophyllum spicatum*) and brittle naiad (*Najas minor*) were observed and a vegetation survey indicated occurrence in 2% and 9% of sites respectively. Eurasian watermilfoil was immediately pulled and treated with granular Triclopyr herbicide. Reducing carp density allowed native and invasive macrophytes to increase, but the increasing abundance of invasives will require additional management to further restore a native plant community.

The State of the State of Old World Climbing Fern in Florida
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Old World Climbing Fern (*Lygodium microphyllum*) is currently one of the greatest threats Florida natural areas land managers face. In the last fifteen years, Florida has dedicated substantial resources to address this problem. Through the efforts of the Florida Exotic Pest Plant Council (FL-EPPC), many public agencies and private organizations have come together through the Lygodium Task Force, which was conceived in the late 1990's. The task force produced two Lygodium management plans in 2001 and 2006. These documents have been indispensable in providing the known history, biology, ecology, and management of OWCF. Additionally, they include a substantial number of stakeholder unanswered questions regarding this troublesome species. Since 2006, however, there has been limited Lygodium task force activity and many land managers have expressed some concern about this. In 2015, we initiated a project with SFWMD to assess the "State of the State" of OWCF in Florida. We reviewed all published *Lygodium microphyllum* literature since 2006 to determine what scientific advances had occurred and what questions were still unanswered. We also interviewed over 35 different individuals that represented national, state, and local land managing agencies, academic institutions, contractors, and conservation groups involved in Lygodium management. We asked each individual a series of questions designed to assess their successes, failures, ideas, and needs regarding OWCF management. This presentation will examine key findings from this project and discuss a roadmap forward to reinvigorate the Lygodium Task Force.

Influence of Dissolved and Particulate Organic Carbon on Exposures of an SCP Algaecide and Consequent Responses of *Microcystis aeruginosa (Student Presentation)*
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Sodium carbonate peroxyhydrate algaecides (SCP) employ H_2O_2 as an oxidant to control the growth of problematic algae and restore uses of critical water resources. The amount of H_2O_2 per cell required to control problematic algae (i.e. dose) can be used to scale exposures for densities of algae encountered in situ. However, oxidizable constituents in a water resource (i.e. dissolved and particulate organic carbon) can alter the dose of H_2O_2 reaching each algal cell, increasing the concentration of H_2O_2 necessary to achieve a desired response endpoint (i.e. EC_{50}). The overall objective of this study was to measure the influence of organic carbon (particulate [POC] and dissolved [DOC]) on exposures of an SCP algaecide and consequent responses of the problematic alga *Microcystis aeruginosa*. To achieve this overall objective, 96-h median effects concentrations (96-h EC_{50} values) for a range of cell densities of *M. aeruginosa* exposed to H_2O_2 as SCP were measured and compared. As the density of algae increased from 9.72x105 to 2.31x107 cells mL^{-1}, measured 96-h EC_{50} values for *M. aeruginosa* in terms of cell density increased from 0.9 mg H_2O_2/L to 30.9 mg H_2O_2/L. The calculated dose of H_2O_2 as SCP achieving these EC_{50} values increased concomitantly with cell density from 8.79 x10-10 mg H_2O_2 /cell to 1.34x10-9 mg H_2O_2 /cell.

Required doses likely increased due to competitive reactions between H_2O_2 and algal-related DOC, as increases in cell density and the dose achieving EC_{50} values were coupled with an increase in DOC from 4±1 mg/L to 24±1 mg/L. When designing in situ treatments for problematic algae using an SCP algaecide, both the density of algae and DOC can be used to scale exposures of SCP. Based on the mass of SCP that can be applied to a water resource, there is a limit to the density of algae that can be controlled with a single application. Implementing a treatment before this density is achieved increases the likelihood of success with a single treatment and decreases the amount of product required, decreasing costs associated with treatment and potential risks for non-target organisms. Incorporating algal density and DOC concentrations into predictions of effective algaecide applications could decrease the possibility of applying an ineffective concentration and maintain margins of safety for non-target organisms.

Vegetative Reproductive Ability of Crested Floating Heart (*Nymphoides cristata*)
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Crested floating heart is an ornamental water garden plant that escaped cultivation and invaded waters in the southeastern U.S. The species is listed as a noxious weed in Florida and causes significant problems elsewhere, including in the Santee Cooper reservoir in the Carolinas, where it has colonized more than 5,000 surface acres. Little is known about the reproductive potential of crested floating heart, but most recruitment seems to result from clusters of rhizomes that are colloquially referred to as ramets. We evaluated the effects of substrate composition and fertility on ramet production in crested floating heart. Single plants were plugged into dishpans filled with one of five substrate mixes that were amended with one of four fertilizer rates and cultured under submersed conditions for 6 months. Analyses of variance 6 months after planting revealed that substrate composition had an early but weak effect on ramet production and that there was no interaction between the main effects of substrate composition and fertility level. However, there is strong evidence that fertility level drives ramet production by crested floating heart. Ramet production was lowest in plants cultured with 0 g/L of fertilizer and highest in plants cultured with 4 g/L fertilizer. These results suggest that aquatic systems with high levels of sediment nutrients are most likely to experience severe infestations of crested floating heart.

An Evaluation of Past and Present Aeration Designs: An Ohio Case Study
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Silver Lake, located in Summit County, Ohio is a 99-acre dimictic impoundment, constructed in the mid to late 1800's. It is a groundwater-dominated seepage lake that until the early 1970's received varying degrees of wastewater. Legacy nutrients from these periods has maintained the lake's status as eutrophic, despite improvements in the watershed (i.e., diverted septic). The lake continually exhibits dense blue-green algal blooms, low clarity (<1m), and summer anoxia below 4m. Further restoration efforts were initiated in the early 1980's that attempted to address legacy nutrients with the goal of immediately suppressing eutrophication symptoms. A bottom diffused aeration system was chosen to meet these goals and was installed in 1982. The basis of the aeration design reflects research and technology of the time. The aeration system delivered 119 cubic feet per minute (cfm) air to the deepest area of the lake (12m), through a CPVC flexible pipe with 1/16 inch holes. Results showed improved oxygen in the deep area and an increase in zooplankton and benthic macroinvertebrates. However, there were also increases in surface chlorophyll-a, phosphorus, and algal biomass, as well as a slight decline in transparency and the continued predominance of blue-green algae. One of the main goals for the aeration project was to reduce the presence of blue-green algae and microcystin counts, which was not achieved with the 1982 aeration design. Despite the systems failure, it was continually run until the compressor broke down sometime in the 1990's. In 2014, a redesigned aeration system was installed that reflected improved sizing models and new aeration technology. The 2014 aeration design, delivered slightly more air (168cfm) from the 1982 design, but the air was more evenly distributed throughout the lake using fine pore EPDM membranes. Results for the redesigned system showed complete lake destratification, significant reductions in chlorophyll and microcystin counts, improved transparency, and finally a shift from blue-green algae to green algae. Overall, the redesigned aeration system has met stakeholder goals of reduced algal biomass and microcystin counts.

The Effects of Organic Matter Content, Nitrogen, and Phosphorus on Growth of Illinois Pondweed *(Student Presentation)*

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There are regions within lakes that tend to support growth of certain plant species to the exclusion of others. This is likely due to differences in soil composition in those specific regions. Most Illinois pondweed (I. pondweed) populations in Florida are observed growing in relatively sandy soils, but there are few if any studies that address whether or not substrate composition affects growth. Nutrient requirements of submersed vascular plants are also not well understood and have only been studied on a few species. The objectives of this research were to determine the effects of organic matter (OM) content on growth of I. pondweed and to assess sediment nitrogen and phosphorus concentrations on I. pondweed growth compared to the nutrient effects on 2 other species; hydrilla and naiad. In I. pondweed, maximum above ground biomass was produced at 0.4% OM and any addition of OM beyond that did not affect growth. All 3 species showed growth responses to soil concentrations of N from 0 to 1500 mg/kg sand. In both I. pondweed and naiad, maximum above ground biomass was produced at 75 mg N/kg sand, whereas hydrilla biomass production was maximized at 150 mg N/kg sand. Any addition of nitrate past those concentrations reduced growth. All 3 species showed growth responses to soil concentrations of P from 0 to 360 mg/kg sand. In both I. pondweed and naiad, growth was increased with the addition of superphosphate and was greatest at 90 mg P/kg sand. Any addition of superphosphate beyond those concentrations did not affect growth of either species. Hydrilla also increased biomass production with the addition of superphosphate, but was not maximized until 180 mg P/kg sand. Hydrilla produced 10 to 20 times more biomass compared to the native species. The reason for this much greater growth is unknown, but might be related to greater efficiency of nutrient use which contributes to its invasiveness.

Control of Dreissenid Mussels with a more Rational Use of Copper

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Zebra and quagga mussels have had profound impacts on native species and the aquatic environment in general, including tremendous economic damage by fouling infrastructure such as pipelines, intakes, screens, pumps, cooling systems and other systems. Managers and maintenance crews in many areas have responded by using various forms of chlorine and/or permanganate to discourage infestation, despite the fact that neither chemical is specifically labeled for this purpose and each has significant drawbacks. In 2013, a liquid formulation of copper was approved by the EPA for control of Dreissenids in lakes, open waters, pipelines, and flowing waters, making it the only product that is both NSF-certified for drinking water and legally labeled as a Dreissenid molluscicide. Field experience shows that mussels can be successfully controlled at surprisingly low doses of soluble copper. Dose-response data from municipal WTPs that have adopted use of liquid copper ions to control zebras and quaggas will be presented. Results of Rapid Response efforts to eradicate mussels in lakes will also be presented.

Evaluating the Sensitivity of Seven Aquatic Plants to Procellacor™ Herbicide *(Student Presentation)*

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The herbicide Procellacor is a new arylpicolinate herbicide currently under development for weed management in rice (*Oryza sativa* L.) production, aquatic weed management and other uses. Greenhouse research at NC State University was conducted to evaluate the effect of the parent compound and an acid metabolite of Procellacor on seven aquatic plant species: alligatorweed [*Alternanthera philoxeroides* (Mart.) Griseb.], Carolina waterhyssop [*Bacopa monnieri* (L.) Pennell], fanwort (*Cabomba caroliniana* Gray), monoecious hydrilla [*Hydrilla verticillata* (L. f.) Royle], parrotfeather [*Myriophyllum aquaticum* (Vell.) Verdc.], variable watermilfoil (*Myriophyllum heterophyllum* Michx.), and American waterwillow [*Justicia americana* (L.) Vahl]. In-water applications of the two compounds were applied at rates of 0 to 81 µgL-1. Fanwort was not controlled by the parent compound at the rates tested, in contrast to the other species evaluated. Dry weight 50% effective concentration (EC_{50}) values were

< 1 μgL^{-1} of the parent compound for alligatorweed, monoecious hydrilla, parrotfeather, and variable watermilfoil. Carolina water hyssop and American Waterwillow EC_{50} values for the parent compound were 5.0 μgL^{-1} and 5.2 μgL^{-1} respectively. These six species were less sensitive to the acid metabolite with dry weight EC_{50} values of 1.6 μgL^{-1} to 77.1 μgL^{-1}. Plant control ratings also indicated that response of the six sensitive species increased from 2 to 4 weeks after treatment. Overall this new product to the aquatics market appears to provide highly effective control of some of the most troublesome invasive aquatic plants in the U.S.

Collaborative Research on Invasive Aquatic Plant Management, a Consultant's Perspective
Paul J. Hausler
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The recent inception of a state-wide invasive species competitive grant program in Michigan may provide a viable means of funding collaborative research and improving practical management strategies. However, the apparent lack of understanding of the role of the consultant in lake management projects by grant application writers makes these projects less desirable from a profit/loss standpoint. I will discuss different aspects of an ongoing project evaluating the effectiveness of traditional and novel approaches to the management of invasive exotic species. The need for project design and coordination by a professional lake management consultant is an often overlooked but necessary component of the overall research project implementation and can be the vital link between good research and practical application.

Monitoring and Research Advancements of Invasive Milfoil Control
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A Cooperative Research and Development Agreement between the Wisconsin Department of Natural Resources and U.S. Army Corps of Engineers Research and Development Center in conjunction with significant participation by private lake management consultants have coupled quantitative aquatic plant monitoring with field-collected herbicide concentration data to evaluate efficacy, selectivity, and longevity of chemical control strategies implemented on a subset of Wisconsin waterbodies. This largely consists of implementing early-season herbicide control strategies targeting Eurasian water milfoil (*Myriophyllum spicatum*, EWM) and hybrid water milfoil (*Myriophyllum spicatum* x *M. sibiricum*, HWM), either as spatially targeted small-scale spot treatments or low-dose, large-scale (whole lake) treatments. This presentation will examine a subset of the research findings, including variability in observed herbicide degradation patterns, in lake movement of herbicides, and differing responses of EWM and HWM to treatment strategies. Further, this presentation will highlight several case studies to understand how this current research is being applied in practice, including longer-tem monitoring of several WI lakes in which whole-lake use patterns of fluridone and combination 2,4-D/endothall targeting HWM were conducted.

Potential Spread of Hydrilla (*Hydrilla verticillata*) to the Great Lakes Basin (*Student Presentation*)
Kristen M. Hebebrand and Jonathan M. Bossenbroek
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Hydrilla (*Hydrilla verticillata*), an invasive aquatic plant, threatens to invade the Great Lakes basin. Hydrilla creates dense webs that choke out native vegetation, reduces flow in canals, clogs water intakes, and interferes with navigation of watercraft. Recreational boating is a primary vector of spread for many aquatic invasive species, including hydrilla. The goal of this project is to predict the overland spread of hydrilla via recreational boating to the Great Lakes Basin using a gravity model. The model data requirements include: boater registrations, hydrilla occurrences, waterbody data, road networks, and watershed. The model was first parameterized based on the historical spread of hydrilla. Then, based on the 2015 distribution of hydrilla, the model predicts where hydrilla will potentially spread over the next 10 years in the continental U.S. Our results provide a relative ranking of watersheds most at risk to new introductions of hydrilla. The results of this model will contribute to a larger risk assessment and help prioritize management efforts.

PROCELLACOR™ – A Novel Herbicide Technology in Development for Aquatic Plant Management
Mark A. Heilman
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Aquatic weed control is challenged by the low numbers of herbicides registered for aquatic use. History has shown that discovery and registration of new herbicide actives suitable for direct application to water is a difficult process. It is extremely rare to discover a candidate product with sufficient herbicidal activity on one or more key aquatic weeds and strong environmental profile necessary to pursue aquatic registration. Management of aquatic invasive and nuisance plants is faced with increasing regulatory and technical challenges such as herbicide resistance, new weed species introductions, threatened and endangered species and infestations in higher exchange systems. New herbicide technology is much-needed to sustain the long-term success of past and current management. PROCELLACOR™ is a novel herbicide technology under development for aquatic use and anticipated for USEPA approval by mid-2017. PROCELLACOR (herbicide common name pending) has unique, low-rate, systemic activity for selective control of the major submersed weeds hydrilla (*Hydrilla verticillata*) and Eurasian watermilfoil (*Myriophyllum spicatum*), including Eurasian X Northern (*M. sibiricum*) hybrid watermilfoils. It shows good selectivity to native submersed vegetation such as tapegrass (*Vallisneria americana*), common waterweed (*Elodea canadensis*), and pondweeds (*Potamogeton* spp.) and common native emergent plants. It also has selective foliar activity for treatment of certain emergent/floating invasive and nuisance aquatic plants such as invasive floating heart (*Nymphoides* spp.), water hyacinth (*Eichhornia crassipes*), and primrose (*Ludwigia* spp.). In studies for registration, PROCELLACOR shows no mammalian toxicity and an excellent environmental profile for use in water indicating wide margins of safety to fish and wildlife. The technical properties of PROCELLACOR for its major aquatic weed control uses will be reviewed along with the most recent data from laboratory and outdoor mesocosm efficacy studies and experimental field trials.

Competition of Select Submersed Aquatic Plants with Hydrilla in a Cool and a Warm Climate *(Student Presentation)*
Amy Henry, Tyler Harris, and Robert J. Richardson
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Hydrilla verticillata is one of the most invasive aquatic plants in the United States. There are two biotypes in the U.S., a female dioecious form that is primarily found in the southern tier and a monoecious form has invaded North Carolina and states to the north. To compare the effect of climate on hydrilla growth and interspecific competition, mesocosms were established in Raleigh, NC, as well as in Laurel Springs, NC. Laurel Springs is approximately 975 m above sea level and represents a northern climate. One plant of each species of *Elodea canadensis*, *Potamogeton crispus*, *Myriophyllum spicatum*, and *Vallisneria americana* was planted in a pot with either zero, two, or four hydrilla plants. The longest stem of each plant was measured biweekly, with surface percent coverage and physiological stages noted. After harvesting at the end of the growing season, the dry weights of the plants at both sites were weighed, and any differences were analyzed. Axillary turions and subterranean turions were collected at harvest from the hydrilla plants, and weight, length, and diameter were recorded. Hydrilla biomass as well as the number of propagules produced was greater at Raleigh than at Laurel Springs. Hydrilla biomass was also reduced when grown in competition with elodea as compared to grown alone. The results of this work will contribute to a larger risk assessment for hydrilla in the Great Lakes basin and help prioritize management/control efforts.

Eradicating Aquatic Weeds - Success and Progress
Deborah E. Hofstra[1], John S. Clayton[2], and Paul D. Champion[2]
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Introduced submerged aquatic plants have successfully invaded many New Zealand lakes, often forming dense mono-specific stands or weedbeds. Dense weedbeds displace desirable native plants, and can result in low levels of dissolved oxygen that locally degrade fish and wildlife habitat. Weedbeds can also reduce amenity and utility values such as swimming, angling, boat access and the use of waterways for drainage, irrigation and hydroelectric power generation. As well as protecting the amenity and utility functions of susceptible waterbodies, there is a

growing desire to control or eradicate invasive aquatic plants to support the restoration of lakes for intrinsic values, such as improving biodiversity and native habitat. Amongst the weed control methods available, herbicide and the herbivorous fish grass carp have been used to eradicate submerged weeds from several lakes, with significant weed reduction and progress towards eradication achieved in other lakes. Field observations, lakes case-studies and experimental research have been used to determine the critical factors for success, including waterbody types, timing and target weeds.

Correlation of Hydroacoustic Biovolume Estimation to Submersed Plant Biomass *(Student Presentation)*
Andrew Howell and Robert J. Richardson
North Carolina State University, Crop Science Department, Raleigh, NC

Invasive submersed aquatic vegetation (SAV), such as *Hydrilla verticillata*, can negatively impact lentic and lotic systems by impeding recreational activities, power generation, and significantly disrupting native ecological function. Annually, the U.S. collectively spends an excess of $100 million for aquatic weed management, which includes costs associated with scouting, monitoring and controlling the invasions. Early SAV detection and accurate mapping is critical to formulating management decisions and timely incorporation of management practices. Traditional in situ sampling techniques have been widely utilized, but often require significant labor, which limits the scale of sampling and the rapidness of processing. It can also be difficult to approximate specific plant biomass levels using these methods, especially in scenarios of high plant diversity. Advances in hydroacoustic technology and data processing offer the opportunity to estimate SAV biomass at scale with reduced labor requirements. Research was conducted at two North Carolina reservoirs to compare estimated SAV biovolume from consumer grade hydroacoustic technology to submersed biomass measurements. Biovolume and biomass were found significantly positively correlated in both data sets, with a correlation coefficient of 0.8343 ($p < 0.0001$) at Shearon Harris and 0.5129 ($p < 0.0001$) at Roanoke Rapids test sites. Results from both scenarios suggest that as biovolume increases, so does SAV biomass in a non-linear trend. Implications from this study may prove extremely useful for comparing before and after treatment effects on both a spatial and temporal level.

Total Lake Vegetation Mapping Utilizing Sonar Plus Other Sensing Technologies
Steve T. Hoyle, Andrew Howell, and Robert J. Richardson
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Traditional surveys for aquatic plant management activities have incorporated visual estimates, aerial photography or satellite imagery. Even though each can be useful, the recent advances in Sonar technology and the rapid adoption of this technology have allowed managers an opportunity to get almost real time submersed plant information. We have attempted to bring the plant mapping above the water's surface where Sonar is ineffective. A new approach to this is to utilize boat-based platforms which include a GreenSeeker, visual video camera and possibly a small multispectral camera. This method should allow for lower cost and faster data turnaround time than aerial or satellite imagery. Data can be geo-synchronized to the Sonar unit to provide accurate results.

The Michigan Aquatic Nuisance Plant Species Program
Lisa Huberty
Michigan Department of Environmental Quality, Aquatic Nuisance Control Program, Water Resources Division, Lansing, MI

Influence of Copper Algaecide Concentration and Formulation on Aqueous Microcystin-LR Degradation *(Student Presentation)*
Kyla J. Iwinski[1], Ciera M. Kinley[2], Alyssa Calomeni[2], Tyler Geer[2], and John Rodgers, Jr.[2]
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The potential influences of copper algaecide concentration and formulation on rates and extents of MCLR degradation were investigated in this study. In laboratory experiments, the MCLR producing cyanobacteria *Microcystis aeruginosa* was exposed to a series of copper concentrations (0, 0.1, 0.5 1.0, and 5.0 mg Cu/L) of three copper-based algaecides: a copper salt ($CuSO_4$), a chelated copper-ethanolamine (Cutrine-Plus®), and a chelated copper-citrate and copper-gluconate (Algimycin-PWF®). Following copper exposures, aqueous and total MCLR

concentrations were measured over time for 14 days, and rates and extents of MCLR degradation were calculated. MCLR degradation rates and half-lives ranged from -4.8 to -2.4 µg MCLR/L hr^{-1} and 22.5-34.6 hours, respectively, at copper concentrations of 0 to 1.0 mg Cu/L. Aqueous MCLR concentrations following exposure to 0-1.0 mg Cu/L declined from peak measured concentrations (171-241 µg/L MCLRAq) to pre-treatment MCLRAq concentrations (~41 µg/L) within 3-4 days after copper exposure, and were either at or below detection limit (2 µg/L MCLR) within 7-10 days. Following exposure to 5.0 mg Cu/L, MCLR concentrations had not significantly decreased by 14 days after copper treatments; therefore, degradation rates and half-lives could not be calculated. Results of this study revealed that copper concentration can influence degradation rates of MCLR, however this influence was not significantly different from untreated controls within copper algaecide concentrations currently registered for use (0.1 – 1.0 mg Cu/L). Copper formulation did not significantly alter degradation rates at comparable copper concentrations. These data provide a more thorough understanding of the influences of copper algaecides on MCLR degradation over time, and may be used to inform more accurate risk evaluations and use of copper-based algaecides for management of MCLR producing *M. aeruginosa*.

Evaluation of EcoAnalytics and Canopeo: Tools to Assist with Aquatic Plant Surveys and Impacts of Herbicide Treatments

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Resource management agencies are increasingly including use of point intercept and hydroacoustic surveys to help with planning and assessment of aquatic plant control operations. Plant species density layers are being combined with complementary hydroacoustic biovolume (percent of water column occupied by vegetation) data utilizing GIS overlay methodology to help visualize species distribution and abundance. EcoAnalytics is a technology under development that automates processing, analysis, and visualization of point intercept data and overlay with processed hydroacoustic data without the need for complex or expensive GIS software packages. EcoAnalytics is a cloud based system comprised of three components including a field collection application, database and website for viewing processed data. We will discuss our use of EcoAnalytics in field monitoring projects. Canopeo is a rapid and accurate green canopy cover measurement tool developed by Oklahoma State University. Canopeo is used to quantify the percent canopy cover of live green vegetation based on an overhead photo with a mobile device. It is also a cloud based system comprised of a field application, database and website. Although developed for use on agricultural crops, turf or grasslands, it has proven to be adaptable and useful in aquatics for monitoring treatment efficacy, impacts to non-target emergent vegetation, and in plant phenology studies. Examples of studies on water hyacinth (*Eichhornia crassipes*), Nuphar (*Nuphar adv*ena), and native Kissimmee grass (*Paspalidium geminatum*) conducted on Lake Kissimmee in central Florida will be discussed. Canopeo can provide a quantitative assessment of general plant health and injury, and while further studies are required, results to date suggest a role for this application in aquatic plant management. As these tools are refined, they may provide the ability to rapidly generate data to guide management decisions, evaluate outcomes, and provide a quantitative means for better addressing stakeholder questions.

A Novel High-throughput Genotyping Assay for Distinguishing *Myriophyllum* spp. and their Hybrids *(Student Presentation)*

Kallie C. Kessler[1], Eric L. Patterson[1], Margaret B. Fleming[2], Scott J. Nissen[1], and Todd A. Gaines[1]
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Hybrid watermilfoil (*Myriophyllum spicatum* X *M. sibiricum*) requires higher application rates of many commonly used herbicides compared to the invasive parent, Eurasian watermilfoil (*Myriophyllum spicatum*), making accurate species identification prior to application vital to successful management. Since morphological features have proven unreliable in species identification, several genotyping tests have been developed. Initially, single nucleotide polymorphism (SNP) characterization was performed by cloning polymerase chain reaction (PCR) fragments into *E. coli* and sequencing the plasmid. This process was lengthy and expensive. Species identification

improved with the development of a PCR restriction fragment length polymorphism (PCR-RFLP) which eliminates the cloning and sequencing steps and drastically decreasing the amount of work required for positive species identification. While a PCR-RFLP assay was a great improvement, there are more cost effective and accurate methods. Currently, Kompetitive Allele Specific PCR (KASP) assay is the dominant technique used to identify SNPs in several fields including directed breeding. In this application, we developed a KASP assay for rapid and high-throughput SNP identification for milfoil species identification. Our KASP assay relies on the competition between two species-specific primers, one primer is tagged with a HEX probe while the other is tagged with a FAM probe. By measuring the ratio of HEX and FAM probe fluorescence at the end point of a PCR, we can clearly distinguish between both parental and hybrid genotypes. Three primer sets were designed using the ITS sequence identified in previous genotyping assays. The three primer sets were tested on milfoil populations from lakes in Colorado and Wisconsin and several lab strains that had been previously identified by traditional methods. This new assay provides quick, inexpensive, and conclusive genetic identification of milfoil species that will provide lake mangers with a detailed description of target populations, aiding in the selection of appropriate herbicides and application rates.

2,4-D Metabolism in Eurasian Watermilfoil (*Myriophyllum spicatum*) and Several 2,4-D Tolerant Milfoil Hybrid Populations (*M. spicatum* X *M. sibiricum*) *(Student Poster Presentation)*

Kallie C. Kessler, Mirella Ortiz, and Scott J. Nissen
Colorado State University, Fort Collins, CO

Previous to the discovery of hybrid milfoil populations (*Myriophyllum spicatum* X *M. sibiricum*), 2,4-D was the most cost effective method available to control this invasive species; however, the evolution of herbicide-tolerant hybrids has raised concerns about the availability and cost of future management options. The objective of this research was to determine the physiological basis of hybrid 2,4-D tolerance. We hypothesized that hybrid individuals would produce novel metabolites and/or metabolize 2,4-D at a faster rate than the invasive parent, Eurasian watermilfoil (*M. spicatum*; EWM). To test this hypothesis, apical meristems (10 cm) of EWM and hybrid populations were placed, unrooted, in 4 L glass mesocosm filled with 3 L of dechlorinated tap water. After four days, each mesocosm was treated with 250 µg L^{-1} 2,4-D amine (Clean Amine, Loveland Products, Inc.) and supplemented with 17 KBq ^{14}C ring labeled 2,4-D amine. Herbicide metabolism was evaluated over a 192 hour time course where at each time point three plants from each population were randomly selected, harvested, and dipped in liquid nitrogen to stop all metabolic activity. Herbicide metabolism was quantified using High Performance Liquid Chromatography paired with radioactive detection. All data were analyzed using nonlinear regression. In a preliminary study using a higher rate of 2,4-D (1 mg L^{-1}) there was no difference between the 2,4-D metabolism rate of EWM and hybrid populations and metabolite profiles were similar. The rate of 2,4-D metabolism and metabolite profiles in EWM and three hybrid populations will be presented. Future management activities should incorporate resistance management strategies, including integrated weed management principles and the rotation of herbicide modes of action to prevent the further evolution and spread of 2,4-D tolerant hybrids.

Invasional Meltdown in Minnesota Lakes: Non-native Plants Are Winners and Native Plants Are Losers when Common Carp Invade

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The common carp (*Cyprinus carpio*, hereafter carp) is a Eurasian fish species that was introduced to North America over 100 years ago. Where carp invade, damage to aquatic plants and loss of water quality typically follow. However, not all macrophyte species are likely to be equally sensitive to carp, given differences in growth forms, modes of reproduction, light requirements, and other factors. To evaluate the relative sensitivity or tolerance of aquatic plants to carp, we analyzed a large dataset of aquatic plant and fishery surveys collected by the Minnesota Department of Natural Resources. Surveys included 1,811 lakes sampled from 1992 – 2014, with 226 plant species recorded. We used statistical models to separate the effects of carp from other factors, such as geographic region, human development, lake characteristics, and water clarity. We found that carp strongly influenced the probability of occurrence of individual plant species, which were differentiated as showing tolerant, sensitive, or intermediate responses to increasing carp density. Sensitive species were more likely to have

submersed or floating rather than emergent growth forms and were of higher floristic quality (coefficients of conservatism). Tolerant species were more likely to be non-native (Eurasian origin). As carp density increased, aquatic plant communities had lower species richness and functional group diversity and increasing proportions of non-native species. These patterns suggest that carp may cause an "invasional meltdown" in Minnesota lakes, facilitating secondary invasion of non-native plant species that coevolved with carp and may have traits that enable them to better coexist with carp. Targeted removal of carp may be a useful management tool for supporting control of aquatic invasive plants and recovery of desirable native species. Where carp removal is not feasible, incorporating resistant native species into shoreline plantings and other restoration efforts may be helpful.

Effects of Aquatic Herbicides on Brazilian Pepper Tree (*Schinus terebinthifolius*) *(Student Presentation)*
Cody A. Lastinger and Stephen F. Enloe
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Brazilian pepper tree (*Schinus terebinthifolius*) is an invasive species that was brought to Florida from Brazil and Argentina in the late 1800's as an ornamental tree. It has since become an extremely troublesome plant to control and has invaded many ecosystems in Florida, including mangrove communities. Mangroves are vital to Florida's coastal regions, and they provide both critical habitat for wildlife and soil stabilization along the coast. A major issue that plagues Brazilian pepper tree control in mangrove stands is that no selective herbicide treatments have been identified. This has made selective aerial treatment of peppertree infested mangrove islands virtually impossible. Over the last decade, several new herbicides have been registered for aquatic use in Florida. However, their effectiveness on Brazilian peppertree has not been tested. Therefore, our initial objective was to examine the response of Brazilian peppertree to all of the newer herbicides that are labeled for use in or around water bodies in the state of Florida. Brazilian pepper tree was grown in one gallon pots from seed in a greenhouse for six months to an average height of 30 inches. Herbicide treatments included carfentrazone (0.036 kg ai/ha), imazamox (0.138 kg ai/ha), bispyribac (0.073 kg ai/ha), penoxsulam (0.016 kg ai/ha), flumioxazin (0.07 kg ai/ha), and topramezone (0.064 kg ai/ha). We also included all older aquatic labeled herbicides including endothall (2.48 kg ai/ha), glyphosate (0.55 kg ai/ha), 2,4-D (0.367 kg ai/ha), diquat (0.73 kg ai/ha), fluridone (0.04 kg ai/ha), triclopyr (0.55 kg ai/ha), and imazapyr (0.18 kg ai/ha). All herbicides were foliar applied with non-ionic surfactant (0.25% v/v). Pepper tree seedlings, which were no larger than the second compound leaf, were also treated with the same herbicide treatments to test efficacy of herbicides on smaller trees. Seeds were placed into tree tubes and then transplanted into single pots. The seedlings grew until the second compound leaf stage before herbicides were applied. Injury was visually assessed at 90 days after treatment (DAT), on a scale of 0 to 100 with zero being no injury and 100 be complete loss of leaves and dead woody stems. Height of tallest living growth, and above ground biomass was also collected 90 DAT. Data were subjected to analysis of variance in Systat 9.0 and multiple comparisons were done using Fisher's protected LSD at p=0.05. Glyphosate, imazapyr, and imazamox resulted in greater than 50% injury visually at 90 DAT compared to the untreated controls. Triclopyr, diquat, glyphosate, and imazapyr reduced growth height by more than 70% when compared to the untreated controls. Triclopyr, imazapyr, glyphosate, and diquat resulted in biomass reductions of 99, 92, 88, and 83% respectively compared to biomass from the untreated controls. These results indicate limited potential from most of the newer aquatically registered herbicides for Brazilian peppertree control. Future work will include screening all herbicides which resulted in efficacy on Brazilian pepper tree on the four mangrove species native to Florida to determine if there is any selectivity among these herbicides.

AERF Update
Carlton Layne
Aquatic Ecosystem Restoration Foundation, Marietta, GA

Michigan's Aquatic Invasive Species Program – Five Years of Enhancements
Sarah LeSage
Michigan Department of Environmental Quality, Water Resources Division, Lansing, MI

Michigan's first Aquatic Invasive Species State Management Plan was approved by the Federal Aquatic Nuisance Species Task Force in 1996. Initially, the program was implemented with Federal funds and state agencies' efforts were limited and sporadic due to inadequate funding. Beginning in 2010, Great Lakes Restoration Initiative funds

boosted Michigan's efforts to implement a coordinated and holistic program focused on prevention, early detection, and control of aquatic plants and animals. Michigan further enhanced its program in 2015 with new state funds dedicated to a coordinated aquatic and terrestrial invasive species program. Michigan's Invasive Species Grant Program is an integral part of the expanded program with a specific focus area targeting projects that implement and evaluate strategies to eradicate or control aquatic invasive species through integrated and novel management approaches, including new biocontrol options. Preference is given to projects seeking to advance understanding of invasive aquatic plant control and contribute to the development of solutions for long-term inland lake stability.

Hydrilla (*Hydrilla verticillata*) Risk Assessment for the Great Lakes Basin

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Hydrilla (*Hydrilla verticillata*) is one of the world's most invasive aquatic plants with the ability to grow aggressively and spread rapidly, thereby impacting water quality, native aquatic communities, and human use of waterbodies. The monoecious biotype, which is better adapted to survive at higher latitudes than the dioecious biotype, has been documented in several locations in New York and Ohio, raising concerns about its spread throughout the Great Lakes Basin (GLB). To address these concerns, a team led by the U.S. Army Corps of Engineers–Buffalo District is conducting a risk assessment to understand the potential for introduction and establishment of monoecious hydrilla in other areas of the GLB. The objective is to identify areas most vulnerable to invasion based on likelihood of introduction and habitat suitability. Distributional and dispersal modeling are being used to identify suitable habitat in the GLB and evaluate the likelihood of hydrilla spreading to new areas from where it is presently found. Other components of the project include: 1) developing an understanding of the effects of photoperiod, temperature, and interspecies competition on growth of monoecious hydrilla in northern waters through laboratory and field mesocosm studies; 2) assessing ecological, economic, cultural, and social impacts of Hydrilla establishment in the GLB; 3) providing recommendations for prevention, early detection, and rapid response to reduce risk of hydrilla spread; and 4) identifying best management practices (BMPs) for hydrilla control. Recommendations and BMPs will be shared with local, state, and regional stakeholders in the GLB to inform local management priorities as well as regional and GLB-wide planning. High-risk areas will be priorities of outreach to prevent or minimize hydrilla introduction, and if hydrilla is introduced, to ensure early detection and effective management. This presentation will provide a project overview and introduce subsequent presentations regarding specific project elements.

Delta Region Areawide Aquatic Weed Project and the Adaptive Management of Invasive Weeds in the Sacramento / San Joaquin River System

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The Sacramento / San Joaquin River Delta (Delta) is formed by the confluence of the Sacramento and San Joaquin Rivers. The Delta is a vast (68,000-acre) network of waterways and islands formed by the construction of levees. The Delta is critical to the ecology and life history of many aquatic species, but it is also the hub of California's water supply for domestic use and irrigation, a navigation channel to the Ports of Sacramento and Stockton, and recreational fishing and boating. The California Division of Boating and Waterways-CA Department of Parks and Recreation (CDBW) have been managing waterhyacinth (since 1982) and Brazilian waterweed, or egeria, (since 1997) under specific legal authorizations. In 2014, legislation empowered the CDBW to manage other invasive species, such as curlyleaf pondweed. Beginning in 2014, a USDA ARS Areawide Pest Management program was

initiated to develop an adaptive management program to control invasive aquatic plants in the Delta, improve cooperation among agencies, and evaluate the ecological and economic benefits and impacts of invasive species management. Management options include biological, chemical, mechanical, and physical control techniques. Detailed mesocosm and field studies of the ecology, life history, and control of the target species (waterhyacinth, egeria, curlyleaf pondweed, and South American spongeplant) will be implemented to optimize the timing and efficacy of management, test and implement new management techniques, and develop approaches to assess plant population management. In addition, remote sensing technologies such as aerial and satellite imaging and hydroacoustic monitoring, are being investigated to develop decision-support tools for management of invasive aquatic plants in the Delta. The IPM plan will be developed in consultation with the U.S. Fish and Wildlife Service and the National Marine Fisheries Service to address the Endangered Species Act issues for species of concern, including Delta smelt, green sturgeon, steelhead, and chinook salmon.

At the Front of a Storm: What Emerging Federal Processes for Endangered Species Risk Assessment Will Mean to the Registration

Bernalyn D. McGaughey
Compliance Services International, Lakewood, WA

As a result of litigation and seemingly unresolvable differences between the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Endangered Species Act (ESA) pesticide endangered species risk assessment practices, the U.S. EPA Office of Pesticide Programs (OPP), U.S. Department of Interior Fish Wildlife Service (FWS), and U.S. Department of Commerce National Marine Fisheries Services (NMFS; with FWS "the Services") sought mediation through a scientific panel appointed by National Academy of Sciences (Panel). The Panel's deliberation resulted in an expert report on "Assessing Risks to Endangered and Threatened Species from Pesticides," released in April 2013. Since that time, the agencies have applied their interpretation of the Panel's recommendations to an "interim process" for FIFRA risk assessment of species listed by the Endangered Species Act (ESA). If nothing else is clear at this point, it is certain that, in order for the assessment process to be sustainable, agency resources need to focus on the true areas of concern with respect to the intensity of their evaluations. Registrants (and OPP, possibly) would prefer to see the primacy of FIFRA for this standard, but given ESA court decisions and longstanding Services' policy, this is not likely to happen. FIFRA and ESA are incompatible, and given legal history to-date, ESA trumps FIFRA. It will take "all hands on deck" to achieve a predictable, reasonable process, and risk assessment in isolation is not going to resolve matters. This presentation will review the status of FIFRA/ESA evaluations, how the interim process might impact aquatic herbicide uses, and what actions in advance of FIFRA aquatic herbicide review might be helpful.

Field Monitoring and Sampling of Chemically Treated Giant Salvinia in Louisiana and Texas

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Pre- and post-treatment monitoring of chemically treated vegetation is vital to ensure success of an aquatic vegetation management program. Monitoring programs are commonly used to track herbicide efficacy against problematic plants such as hydrilla (*Hydrilla verticillata*), Eurasian watermilfoil (*Myriophyllum spicatum*), and water hyacinth (*Eichhornia crassipes*). In addition to determining herbicide efficacy, monitoring provides useful information on level and rate of herbicide injury, plant recovery, application proficiency, and movement of plants into or out of treatment areas. Since the introduction of giant salvinia (*Salvinia molesta*) into Louisiana and Texas in 1999, herbicides have been the primary tool to combat the invasive floating fern. Although large-scale herbicide treatments targeting the plant have been loosely monitored post-treatment, data collection to statistically quantify and evaluate management success typically has not occurred. Research was conducted at Saline Lake, Louisiana (2015) and Sam Rayburn Reservoir, Texas (2016) to quantify herbicide efficacy on a large-scale basis, and to develop reliable field-sampling techniques. Giant salvinia in Saline Lake (101 ha. block) was treated with glyphosate + diquat, while two sites in Sam Rayburn were treated with glyphosate (10 ha. block) and glyphosate + flumioxazin (19 ha. block). Data was collected pre-treatment and every two weeks throughout the duration of the study (3 months). Parameters measured included percent coverage, percent injury, and percent recovery (new growth). At treatment, giant salvinia coverage was 1 plant layer thick, which allowed for optimal herbicide

exposure. Glyphosate + diquat resulted in rapid injury to giant salvinia and opened large areas (0.1 to 0.5 ha) at Saline Lake; however, plant recovery was noted throughout the treatment area by 49 DAT. Data collection from Sam Rayburn will continue through the summer of 2016.

The Challenges and Techniques of Managing Monoecious Hydrilla in Flowing Water Systems
Justin J. Nawrocki and Robert J. Richardson
North Carolina State University, Crop Science Department, Raleigh, NC

Monoecious hydrilla was first discovered in the Mid-Atlantic region in the early 1980s. Since that time it has spread from small water-bodies to large reservoirs and is now found in ecologically sensitive areas such as rivers and estuaries. Managing hydrilla in these sensitive areas can prove challenging due to extreme water exchange characteristics. Herbicide application techniques originally developed for irrigation canals have found utility in effectively treating monoecious hydrilla in areas like the Lake Cayuga, NY inlet and the Eno River, NC. Larger flowing water systems infested with hydrilla, like the Ohio River, OH or the Chowan River, NC may require the development of new application techniques or herbicide formulations to be cost effective at controlling hydrilla. Another challenge in the effort to control monoecious hydrilla is new state regulations enacted to protect threatened or endangered species or to apply restrictions on all treated water moving outside the treatment zone. Cooperation between chemical manufacturers, herbicide applicators, stakeholders and state and federal regulators will be necessary to address the monoecious hydrilla infestations in these sensitive areas.

The Corps of Engineers Aquatic Plant Control Research Program – An Update
Linda Nelson[1] and Jeremy Crossland[2]
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It is estimated that the U.S. Army Corps of Engineers (USACE) spends more than $140M annually on the prevention, early detection and management of aquatic invasive species; including removal of aquatic plants from waterways and reservoirs that would otherwise obstruct navigation, impede flood control, and impact the success of aquatic ecosystem restoration efforts. The Aquatic Plant Control Research Program (APCRP) accounts for approximately 3% of these annual expenditures. While the USACE is authorized by Section 104 of the River and Harbor Act of 1958 to maintain a comprehensive research program as part of the overall Aquatic Plant Control (APC) Program, funding for aquatic plant research has been limited in recent years, and provided only by special appropriations identified by Congress. Section 1039(d) of the Water Resources and Reform Development Act of 2014 (WRRDA 2014) further amended Section 104 of the River and Harbor Act to expand the existing APC Program to include aquatic invasive species in addition to noxious aquatic plant growths and to provide for prevention as well as control and progressive eradication of these species. In addition, WRRDA 2014 authorized the Secretary of the Army for Civil Works to establish watercraft inspection stations in the Columbia River Basin in the States of Idaho, Montana, Oregon, and Washington. The implementation of these new authorities and the subsequent impacts to the Nation's only federally authorized aquatic plant control research program will be discussed.

Role of Government Research on Regional Aquatic Plant Management Issues: Demonstration Projects
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For over 30 years, the U.S. Army Engineer Research and Development Center Chemical Control Team has focused on a multi-tiered approach to develop scientifically sound laboratory, mesocosm, and field-scale research. Data from these efforts support herbicide use patterns and guidance to resource managers responsible for controlling invasive plants in public waters. A key aspect of that work has been active coordination and direct involvement in large-scale and/or high-profile field demonstrations across the country. While each demonstration has a unique set of circumstances, there are recurring themes that drive these projects: 1) significant stakeholder disagreement regarding proposed management strategies, facilitating collection of unbiased supporting field data; 2) the desire to evaluate/verify an emerging technology on an operational scale; 3) establishing cooperative work

with the private sector and regulatory community to provide third party data; and 4) supporting local resource managers wanting to implement novel strategies. Given the environmental sensitivity and visibility of public water management, these projects can sometimes lead to friction between the research community, applicator/lake manager community, and the resource/regulatory community. Despite these conflicting viewpoints, well-conceived demonstration projects have a proven track record in providing critical information that can support long-term product use patterns. In this presentation, we will briefly discuss past projects and outcomes, and provide more detailed discussion of recent projects on hydrilla (*Hydrilla verticillata*), water soldier (*Stratiotes alloides*), Eurasian and hybrid watermilfoil (*Myriophyllum spicatum*), flowering rush (*Butomus umbellatus*), and Kissimmee grass (*Paspalidium geminatum*). Our overall experience suggests that government research participation in demonstration projects can facilitate development of long-term use patterns, bring additional funding and resources to the projects, and provide a coordinating agency to work with multiple stakeholders.

Factors Affecting Curlyleaf Pondweed Frequency of Occurrence and Relative Density in Managed and Unmanaged Systems: An Analysis of Results from 60 Lakes

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We obtained point intercept surveys of lakes containing curlyleaf pondweed (*Potamogeton crispus*) from agencies, academics, and consulting firms to examine factors that influence the distribution and abundance of curlyleaf pondweed in Minnesota. We only included data sets that had early samples to capture peak curlyleaf growth (early to late June) or early-season/pretreatment samples (April or May). The resultant dataset included 60 lakes, both treated and untreated, with data covering a period of up to 10 years (2006-2015). We standardized samples to depths $\leq$ 3.7m. We matched plant survey data with water quality, length of ice cover, mean snow depth, and years of herbicide treatment to model the effects of these factors on curlyleaf pondweed frequency of occurrence and mean relative abundance (1-4 for sites with plants) using model selection techniques in a generalized linear mixed model approach, with lake as a random variable. For lakes treated with herbicides, the number of years treated was a significant predictor of early-season, pre-treatment curlyleaf frequency and relative abundance, suggesting that repeated treatment with herbicides restricts curlyleaf distribution and abundance in the following spring. Early-season frequency in treated lakes was also influenced by winter conditions (ice duration or snow depth) but relative abundance (where plants occurred) was less influenced by winter. In untreated lakes, early-season curlyleaf frequency and abundance were best predicted by a mixture of environmental factors including mean snow depth, length of ice cover, and previous Secchi depth. More severe winter conditions and repeated treatments created conditions less favorable for curlyleaf pondweed distribution and growth the following spring. For June peak curlyleaf samples, years treated was less important (only current year had an effect) and although winter environmental conditions appeared in some models they were generally not significant. Furthermore, relative abundance was generally less affected by prior treatment or conditions than frequency. Analysis of this data set is shedding light on broad scale factors influencing curlyleaf.

Absorption Rates of 2,4-D Butoxyethyl Ester and 2,4-D Amine by Eurasian Watermilfoil *(Student Presentation)*

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The rate at which herbicides move from the water column into targeted aquatic weeds is important for several reasons. Rapid herbicide absorption would theoretically shorten the concentration exposure time and allow an herbicide to perform well even in areas with high water exchange or as a spot treatment. The herbicide, 2,4-D, is often recommended for Eurasian watermilfoil (*Myriophyllum spicatum*) management because it is cost effective and selective. The dilemma often faced by applicators is whether to make whole lake treatments at reduced rates or high rate applications as spot treatments. The objective of this project was to determine the rates of 2,4-D absorption as a function of the two most popular formulations, butoxy ethyl ester (BEE) and amine, to provide applicators with some research based information about herbicide behavior as a function of formulation. Herbicide absorption was evaluated over a time course of 192 hours using ^{14}C 2,4-D acid mixed with commercial 2,4-D

amine or ^{14}C 2,4-D BEE mixed with cold herbicide both at a rate of 1 µg mL^{-1}. The amine formulation of 2,4-D showed a near linear increase in absorption without reaching maximum 192 hours after treatment (HAT), while 2,4-D BEE reached maximum absorption in the first 6 HAT. Herbicide translocation to milfoil roots was limited for both formulations. These data suggest that in absence of photo-degradation, 2,4-D BEE is well suited for treating areas with high water exchange and for spot treatment because of rapid absorption. Eurasian watermilfoil treated with 2,4-D amine had slower absorption, but given enough time actually accumulated more herbicide.

The Potential for Cryptic Taxa in Aquatic Systems
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Cryptic taxa are taxa that are ecologically distinct but are impossible to tell apart physically. It has become well known in terrestrial systems that the presence of cryptic taxa can have major influences on management decisions and control success. Unfortunately, often, the presence of cryptic taxa is not detected until their influence has become large enough to have major impacts on management success. There are a few well know examples of cryptic taxa in aquatic systems, but how common are they really and how do managers begin to discover if taxonomic groups are more complex than originally thought, and how they can impact management? This presentation will discuss the potential for cryptic taxa and the importance of discovering if taxonomic groups require additional separations into smaller groups. With the use of genetic methods and collaborations between the multiple sectors of the community, this presentation will outline how aquatic plant management can begin to move down the path of effective long term control and potentially spot harmful plant groups before they have the chance to negative influence management success on a regional scale.

Integration of Prevention, Early Detection, and Suppression of Aquatic Invasive Species: An Example from Eurasian Watermilfoil Management
Alejandro Reyes
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Strong prevention, early detection and suppression are key components of aquatic invasive species (A.I.S.) management. Despite the interrelated nature of these components, integrated use is uncommon for lakes, especially smaller systems, where funding may restrict use of all available strategies. One such example is the management of Eurasian Watermilfoil (E.W.M.) in Brant Lake, a 584 ha lake located in the southeastern portion of the Adirondack Park, NY. Currently the Lake Association and the Town of Horicon are using diver-assisted hand harvesting to manage EWM. The lake is also threatened with new potential A.I.S. such as Zebra Mussels, Spiny Water Flea, Asian Clam and Water Chestnut. We present a framework for integrated A.I.S. management using the existing management and prevention strategies, while offering suggestions for future programs aimed at enhancing these programs. We anticipate that these guidelines will have a positive impact on the future of the lake ecosystem.

Ecological Restoration Using Aquatic Mechanical Harvesting
Bruce A. Richards
Weedoo Shoreline Workboats, Inc., Hockessin, DE

Using mechanical harvesting of invasive aquatic plants or macroalgae is a critically important environmentally sensitive method to improve a lake, pond or coastal bay ecosystem. Invasive plants displace native vegetation, fish and invertebrates. Shoreline native wetland plants are overwhelmed with non-native reeds. Physically removing excess vascular plants as well as filamentous and macroalgal species gives the beneficial aquatic organisms a chance to regain lost habitat. Aquatic Mechanical Harvesting has improved shifting techniques giving bycatch ways to return to the water. Unlike other methods, physical removal of plants takes measurable levels of nutrients out of the ecosystem. State and federal regulators mandate reductions of nutrients for specific bodies of water called Total Maximum Daily Loads (TMDLs). Most methods do not remove in situ and anthropogenically derived nutrients in water-bodies. Removal of excess algae and invasive aquatic plants gives the native species time to regain lost habitat. This does not mean you only conduct one removal treatment; the process needs to be periodically repeated. Aquatic Mechanical Harvesting provides organic material suitable for multiple uses including compost, animal feed, and possibly paper. Both algae and invasive aquatics are magnets for

environmental chemicals unintended for healthy water-bodies including: zinc, mercury, pharmaceuticals, synthetic hormones, antibiotics, medical waste, caffeine and PCPs. Physical removal by harvesting reduces sequestered chemicals. Shoreline invasive common reed plants (*Phragmites*) reach 4 meters forming long hollow woody stems. These reeds dry in the fall and are susceptible to fire. Harvesting has unduly been blamed for increasing plant fragmentation. The reality is that two or three harvests during warmer months negates re-growth attributed to fragmentation.

The Role of a University Specialist in Regional Aquatic Plant Management Programs
Robert J. Richardson and Steve T. Hoyle
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Aquatic plant management programs are often developed through a complex mixture of people, personalities, science, and politics. University specialists are frequently in the middle of the maelstrom, and by the nature of our positions, the middle is probably where we should be. Specialists are tasked with three missions at land grant universities: research, teaching, and extension. All three of these are required to develop efficient and effective management programs. Through research, specialists should generate unbiased research data that will facilitate decision making. Through teaching, specialists should train the next generation of managers, researchers, etc., to enter this field of work. Through extension. specialists should "translate science for practical application" and provide science based guidelines for management programs to follow. This presentation will provide examples of the various roles that a university specialist can play in regional aquatic plant management programs.

Control of Taste and Odor Producing Algae in Source Water for Anderson Regional Joint Water System
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The Anderson Regional Joint Water System (ARJWS) has experienced intermittent taste and odor problems in source water from the Six and Twenty Creek arm of Hartwell Lake, Anderson, South Carolina, making it difficult or impossible to provide the quality, odor-free drinking water customers expected. An adaptive management strategy was implemented that began with identifying the source of taste and odor problems as terpene alcohols [2-methylisoboneol (MIB) and geosmin] produced by benthic algae (e.g. cyanobacteria and diatoms). With MIB concentrations reaching hundreds to thousands of parts per trillion in Hartwell Lake in summer months, an algaecide treatment plan was developed based on results from a laboratory study of responses of taste-and-odor producing algae to candidate algaecides. A chelated copper formulation algaecide and a peroxide formulation algaecide (both registered for application to drinking water by the U.S. EPA) were strategically applied to control the benthic algae. Approximately 160 acres of the Hartwell Lake littoral zone (from the water line to the 25' depth contour) and 4 acres around the ARJWS water intake structure were treated. Exposures were monitored in the field and the treatments were modified as necessary following each application through adaptive management to achieve effective control of the target benthic algae. These data were also supplemented with a regimen of sediment and water toxicity tests using sensitive, sentinel fish and invertebrate species. Recent results from treatments and allied laboratory data indicate that MIB and geosmin produced by benthic algae can be efficiently and effectively controlled using a strategic and adaptive algaecide treatment plan.

Integrated Management of Waterhyacinth (*Eichhornia crassipes*) *(Student Presentation)*
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Waterhyacinth is the most intensively managed floating aquatic weed in Florida. It is usually managed with herbicides, most often with 2,4-D. More than $3 million in public money is spent in Florida annually to manage floating aquatic weeds –including waterhyacinth and waterlettuce – in public waters, so even a small reduction in

the amount of herbicide used for waterhyacinth management could represent significant long-term savings for Florida resource managers. Several biocontrol agents are utilized for waterhyacinth management in many countries with mixed results. The newest biocontrol agent for waterhyacinth is *Megamelus scutellaris*, which was first released in 2010 and is currently being evaluated on waterhyacinth in Florida. In these experiments we evaluated the impact of combining different rates of 2,4-D with biological control agents on waterhyacinth growth and development. We used a 3 x 2 factorial with 3 rates of 2,4-D (control, low rate, operational rate) and 2 levels of insect biocontrol (no insects, unrestricted attack by *Neochetina* spp. weevils and *M. scutellaris*) in a RCBD with 5 blocks (replications). Plants were cultured for 3 months after 2,4-D treatments, then rated, harvested and analyzed to evaluate the combined and individual effects of insect biocontrol and herbicide rates on waterhyacinth growth and development. These experiments revealed that herbicide-treated plants without biocontrol insects recovered from 2,4-D damage, while herbicide-treated plants with biocontrol insects did not. These results suggest that it may be possible to reduce 2,4-D applications for waterhyacinth management if biocontrol insects are introduced to, or are present in the treatment area.

Bald Cypress (*Taxodium distichum* (L.) Rich.) Survival and Re-leafing Success in Response to Low GPA Winter Herbicide Applications for Managing Giant Salvinia (*Salvinia molesta* D.S. Mitchell) *(Student Presentation)*

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Populations of giant salvinia (*Salvinia molesta* D.S Mitchell) are often found growing under the canopy of extensive bald cypress stands. These immense stands of bald cypress make it difficult for herbicide applicators to access large populations of giant salvinia. The inability of applicators to access these areas, as well as avoiding direct contact of herbicides to tree foliage and other tree features provides a substantial amount of unmanaged plant material capable of rapidly reproducing and re-infesting previously treated sites; thus, making management efforts null and void. Bald cypress is a deciduous tree and sheds its leaves annually during the winter. The annual shedding of leaves may allow herbicides to be applied uniformly to giant salvinia, either by boat or aircraft, which would otherwise be shaded during the growing season by dense bald cypress canopies. Since the tree is such a valued asset to the state of Louisiana, it is too risky to attempt a large scale winter herbicide application in a field scenario that may have irreversible negative impacts towards the health of bald cypress. To investigate the effects of herbicide applications over the top of bald cypress when foliage is minimal or completely shed, and giant salvinia efficacy, five herbicide treatments at one of the three application timings (December, January, or February) were evaluated. The aquatic herbicides diquat, glyphosate, flumioxazin, and glyphosate + diquat were applied at an equivalent of 94 L ha-1 (10 GPA), which is a spray volume similar to those used by fixed wing or helicopter aquatic herbicide applications. Bald cypress re-leafing and health was assessed weekly by performing repeated measures on three branches (>30 cm) on each tree. Giant salvinia dry weight biomass was also analyzed to test for treatment effects. These data will provide information about which herbicide treatment(s) may be injurious to bald cypress as well as which treatments provide the best giant salvinia control utilizing a low spray volume during the winter. Delayed and abnormal leaf formation, reduced leaf length, irregular canopy production, and no negative effects were observed among herbicide treated bald cypress 4 weeks after initial leaf emergence.

Water Soldier (*Stratiotes aloides*) in Ontario - Preventing Its Spread to the Great Lakes

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Water soldier (*Stratiotes aloides*) is an invasive aquatic plant, native to Eurasia, first observed in the Trent River in Ontario in the fall of 2008 and was the only wild occurrence in North America. It forms dense colonies of floating and submerged vegetation that can aggressively out-compete other aquatic plants and negatively impact the biodiversity of aquatic ecosystems. Water soldier also impedes navigation and recreation. The population at the original infestation area is approximately 160ha, with small satellite populations in three areas, extending approximately 30km downstream. Recognizing the potential negative impacts posed by this invasive plant, the Conference of Great Lakes Governors and Premiers identified water soldier on their "Least Wanted" aquatic invasive species list in 2013 as a priority species for prevention and response. An inter-agency working group

(Ontario Ministry of Natural Resources and Forestry (MNRF), Ontario Federation of Anglers and Hunters, Ontario Ministry of Environment and Climate Change, Trent University, Lower Trent Conservation, U.S. Army Engineer Research and Development Center, Parks Canada, Ontario Invasive Plant Council and Invasive Species Centre) was formed to help coordinate research, monitoring, eradication and prevention strategies, culminating in the development of a draft Integrated Management Plan for Water Soldier in 2014. Based on this plan, control approaches (physical and herbicide) were initiated in the fall of 2014 and are anticipated to occur over several years, with the initial focus on preventing further downstream dispersal of plants and addressing source populations. In tandem with these control measures, the MNRF has been working to address policy and legislative gaps for water soldier (and other aquatic invasive plants), including the introduction of a new Invasive Species Act that would allow Ontario to prohibit the possession, sale, transport and/or release of high risk invasive species and prevent new infestations. This presentation will provide an overview of the suite of actions that have been undertaken to address the threat of water soldier in Ontario and the Great Lakes basin.

Incorporation of Biotype Alters Species Distribution Model Predictions of Suitable Habitat for the Invasive Aquatic Macrophyte *Hydrilla verticillata (Student Poster Presentation)*

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Species distribution models (SDMs) relate known species occurrences and underlying environmental characteristics to develop predictions about habitat requirements and the spatial distribution of suitable habitat. These predictions are useful for a variety of applications including habitat conservation and predicting potential spread of nonindigenous invasive species. Although SDM modelling frameworks and analysis of outputs have received considerable attention, one relatively understudied topic is the extent to which the incorporation of taxonomic information, such as subspecies or biotype, influences predictions. We used Maxent to develop SDMs for the aquatic invasive macrophyte hydrilla (*Hydrilla verticillata*), which occurs in two biotypes (monoecious vs. dioecious) in the U.S. Each biotype demonstrates optimal growth under different climatic conditions. Thus, we hypothesized that SDM incorporation of biotype would influence model performance and improve predictions. We compared Maxent models for monoecious-only, dioecious-only, and all available hydrilla occurrence data in the U.S. All models demonstrated strong predictive performance based on the occurrence data with which they were trained (all-data area under the curve [AUC]=0.910, monoecious-only AUC=0.970, dioecious-only AUC=0947). Models produced using compiled hydrilla occurrence data forecasted potential species range as far west as California and Oregon, northward into the lower Midwest, and regions in Texas, Louisiana, Arkansas, and Florida. Monoecious-only models increased northern range, extending further into the Great Lakes region, and favorable ranges from New Jersey to North Carolina. Dioecious-only models predicted distribution similar to the all-data model, extending into Texas and California with slight decreases of habitat suitability in Louisiana and Arkansas. The results of this work will contribute to a larger risk assessment for hydrilla in the Great Lakes basin and help prioritize management and control efforts. Overall, results indicate that the incorporation of hydrilla biotype occurrence data can influence and improve SDM predications.

Sediment and Nutrient Reduction Using Bacteria

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Organic sediment measurement was taken by driving a 3-m ¾ inch PVC stake into the hardpan of a water body approximately 5-m from shore. Depth was measured by using a meter stick at 4 points around each stake to the hardpan. The data was then averaged. At E8 STA (Stormwater Treatment Area), a 475-l solar bacteria incubator was used to produce Bio-Zyme bacteria and release it daily. The incubators were inoculated monthly with two 1.3-kg Bio-Zyme slow release bags containing bacteria and nutrients. The site was approximately 3-ha. In 13 months the organic sediment reduction was 1.6 cm per month. A study at the PGA Marsh used a 475-l solar bacteria incubator to produce Bio-Zyme bacteria and release it daily. The incubators were inoculated monthly with two 1.3-kg Bio-Zyme slow release bags containing bacteria and nutrients. The site was approximately 3-ha. In 13 months

the organic sediment reduction was 1.6 cm per month. At the PGA Entrance Pond, 1.3-kg of bulk bacteria Bio-Zyme was applied once per week by hand tossing bacteria mixed with water in three locations. The area was approximately 1.4-ha. In 9 months the organic sediment reduction was 1.3 cm per month. PondZilla was applied with a solo backpack sprayer at Martin County Lake. In addition, VitaStim liquid bacteria were applied by 375-l spray tank. Both were applied four times to a STA marsh over 7 months. The area was approximately 1.6-ha. Four 90 x 270-cm cement vaults containing water 51-cm deep were filled with approximately 30-cm of organic sediment. The vaults were continually flushed with 2-l of running water per minute. Three different types of Bio-Zyme bacteria were applied to the tanks. The tanks were divided into 12 plots and the muck depth was measured. At Player Club HOA, five waterways were treated for 90 days with EcoSocks. Each lake had 4-6 sites. Organic sediment was reduced in all lakes. The monthly average reductions for the lakes are: Lake 15 (1.6cm), Lake 20 (.9 cm), Lake 21 (1.8 cm), Lake 22 (2.2 cm) and Lake 40 (2.7 cm). The averages for all lakes combined are 1.8 cm per month. Chlorophyll a, was reduced by 59%, total phosphate 46%, nitrogen 78% and total reactive phosphorus 7% after treating with Bio-Zyme for 6 months.

The Effects of the Contact Herbicide Diquat on Mixed Stands of Flowering Rush and Hardstem Bulrush in Lake Sallie, MN - a Pilot Study

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The invasive aquatic plant *Butomus umbellatus* (flowering rush) is capable of utilizing habitat occupied by native plant species and extirpating those species from a site. In Lake Sallie, MN, flowering rush co-occurs in many sites with *Shoenoplectus acutus* (hardstem bulrush). Currently, monotypic stands of flowering rush in infested areas of Lake Sallie are controlled by injecting two applications of diquat herbicide into the water column four weeks apart during the growing season. However, because bulrush is a desirable native species, herbicide treatments in past years have not been administered in sites containing both flowering rush and hardstem bulrush due to the unknown effects of diquat on bulrush in this lake. In 2015, the Minnesota Department of Natural Resources (MNDNR) permitted a pilot study to be carried out in Lake Sallie investigating the effects of diquat on mixed stands of flowering rush and hardstem bulrush. Two five-acre sites were established: one reference and one treatment. Per the MNDNR permit, data was collected in a non-destructive manner at each site. Within each site we collected bulrush height above sediment, leaf count, flowering rush presence or absence, and flowering rush percent cover before each herbicide application and again four weeks after the last application. Flowering rush aboveground biomass declined throughout the growing season and was not detectable at survey points by the end of the study in the treatment site. Bulrush height above sediment and leaf count did not significantly change during the study in the reference site. Bulrush height above sediment did not change in the treatment site. However, bulrush leaf count increased by 66% in the treatment site suggesting that submersed applications of diquat in mixed stands of flowering rush and hardstem bulrush will selectively control flowering rush without harming hardstem bulrush.

Data Deluge from Automated Sensors: A Problem for Aquatic Plant Management or an Opportunity?

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A recent search of Google Scholar with the term “Sensor Data Deluge” came up with a deluge of hits: 13,400 to be exact. For many of us classically trained in frequentist statistics that deal with small sample sizes, the advent of automated sensors that collect multiple data points per second has forced us to adapt our approach toward statistical analyses. For example, hydroacoustic mapping of aquatic plants has become a mainstream APM technique during the recent past thanks to low costs to acquire the data from consumer sonar devices and automated data processing and map creation with cloud services. But now, the question of whether outputs from two or more surveys are statistically different is moot. They almost always will be because sample sizes often exceed 10,000 per survey and thus generate almost complete confidence in means from sampled areas (e.g., standard errors are miniscule). With automated sensor technology, never before has it been more important to differentiate between statistical and biological significance. Within this context, I present natural interannual dynamics of hydroacoustically assessed aquatic plant biovolume collected over 5 years in one eutrophic Minnesota Lake. Average lakewide plant biovolume ranged from 53% in 2013 to 31% in 2015 without any APM. Statistically

significant? Of course. Biologically significant? Better question. How do we tease apart effects of APM from natural variability within managed systems? The BIG question for the industry and a potential future research direction with automated sensor technology.

Washington Update
Lee VanWychen
Weed Science Society of America, Alexandria, VA

Minnesota's Approach to Management of Invasive Aquatic Plants
Chip Welling
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Management of aquatic plants in Minnesota has been regulated by the Department of Natural Resources (MnDNR) since the 1940s, if not before. Historically, the MnDNR regulated management of aquatic plants by owners of riparian property who wanted access to the lake for recreation. In 1987, Eurasian watermilfoil was discovered in Minnesota and soon became a serious problem in several heavily-used lakes. This led the MnDNR to initiate, not just regulate, management of aquatic plants. From the beginning, this management involved a variety of partners, including lake associations, other lake users, local units of government, commercial herbicide applicators or harvesters, consultants, manufacturers of herbicides or harvesting equipment, and researchers. In the development of projects to manage invasive aquatic plants, the MnDNR works with partners to identify realistic goals, consider potential risks associated with options for management, provide funding in some cases, and monitor outcomes. In recent years, the numbers of projects done to manage invasive aquatic plants has increased. Most of these projects are initiated by lake associations or local units of government. The roles of the MnDNR include issuance of permits to allow treatments, a regulatory responsibility, and providing technical and financial support. The MnDNR and our partners rely on results of research to refine approaches to management and understand the effects on Minnesota's lakes of invasion by non-native aquatic plants. A review of some key projects will demonstrate the importance of the roles played by various partners in different stages of development and implementation of projects to manage invasive aquatic plants in Minnesota.

Mesocosm Evaluations on Hybrid Milfoil from Three Wisconsin Lakes
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Hybrid milfoil (*Myriophyllum spicatum* X *Myriophyllum sibiricum*) is becoming more and more dominant in Midwestern lakes given the effective management of Eurasian watermilfoil (*Myriophyllum spicatum*). It has been reported under laboratory conditions that hybrid milfoil is more tolerant to 2,4-D and fluridone than the parental Eurasian watermilfoil species. To date there are few reliable management recommendations for this hybrid, and to address reported failed applications it would be advantageous to develop new recommendations under mesocosm conditions. During the growing season of 2015, milfoil was harvested from Hancock Lake, Legend Lake, and Forest Lake in Wisconsin and shipped to Lonza's Aquatic Plant Research Facility in Alpharetta, GA. Plants from each lake were subjected to a replicated mesocosm study using select treatments of herbicides, algaecides, and aquatic adjuvants. Plants from Hancock Lake treated 2,4-D alone and with combinations of endothall or copper, were reduced by 96-100% when compared to untreated reference plants. The hybrid watermilfoil from Hancock Lake was sensitive to 2,4-D at concentrations as low as 0.3 mg/L applied alone when using a 7 d exposure. Plants from Legend Lake treated with emulsified copper + 2,4-D, 2,4-D (0.5 mg/L) for 24 h, and 2,4-D (0.3 mg/L) for 7 d reduced biomass by 60 to 73% 5 WAT. Hybrid watermilfoil biomass from Forest Lake was reduced by all herbicide treatments at 5 WAT. All treatments except 2,4-D and endothall offered 90 to 100% biomass reduction by the conclusion of the study regardless of exposure time. These results indicate that the hybrid watermilfoil populations from the three lakes utilized in this study remain sensitive to 2,4-D given the concentrations and exposure times used. Current results also provide alternative treatments utilizing herbicide and algaecide combinations as well as an adjuvant that could be used in managing this new invader.

Effective Management of Starry Stonewort

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Understanding the biology, growth characteristics and morphology of Starry Stonewort (SSW; *Nitellopsis obtusa*), is crucial for developing effective chemical control strategies. Despite many algaecides having some documented activity, SSW biology and lineage (Charophyceae: Streptophyta) describes them as the most advanced of the algae and in the same group as higher vascular plants. The common ancestry of SSW and vascular plants indicates some herbicides could have practical utility for control more than algaecides. The unique growth characteristics of SSW have created difficultly for liquid applications to penetrate and interact deep within their pillow like mats. The presence of bulbils, or rhizoidal tissue that may survive treatment can influence the longevity of chemical control methods for this unique macro alga. Algaecide/herbicide formulations with the ability to penetrate and target the rhizoidal tissue of SSW have the potential to greatly improve treatment performance, specifically by increasing longevity of control. Bench scale testing has indicated the ethylene diamine copper complex as a potent active ingredient for control of both vegetative and rhizoidal tissue (bulbils). The granular chelated copper (i.e. Komeen Crystal®), can provide a targeted and enhanced exposure of the ethylene diamine copper complex on SSW rhizoidal tissue, and appears as an ideal candidate for increased extent and longevity of SSW control. In this presentation we will review results from controlled bench scale studies used to develop use patterns for SSW control as well as discuss results of ongoing field trials.

Biology and Management of Monoecious Hydrilla (*Hydrilla verticillata*) *(Student Presentation)*

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The monoecious biotype of hydrilla (*Hydrilla verticillata*) is an invasive submersed macrophyte that is spreading into northern tier states. The biology and management of this biotype has not been as intensively studied as its dioecious counterpart to the South. We conducted a series of small-scale studies to improve our knowledge on monoecious hydrilla. To develop a better understanding of how short-term growth rates are influenced by temperature and photoperiod, we compared monoecious hydrilla to the dioecious biotype, and Eurasian watermilfoil (*Myriophyllum spicatum*) and elodea (*Elodea canadensis*), two northern cold-water specialists. Results from the growth chambers suggest that monoecious hydrilla growth was very limited at temperatures below 21° C, with a rapid increase in growth rates as water temperatures increased from 21° to 25°C. We observed limited difference in growth between a 12 and 16-hour photoperiod over the 28-day evaluation. Growth rates of the other species in comparison to monoecious hydrilla will be discussed. Laboratory and greenhouse evaluation of hydrilla growth under varying light regimes indicate growth can occur at light levels as low as 10 to 20 µmol m^2 sec^1. With the lack of information regarding herbicide sensitivity of monoecious hydrilla, the efficacy of slow acting enzyme inhibitors and fast acting contact herbicides was evaluated. Fluridone and penoxsulam were highly active on monoecious hydrilla at rates as low as 3 µg/L. Response of monoecious hydrilla to all herbicides will be discussed. Our results suggest monoecious hydrilla growth is not favored under cooler water conditions, and while photoperiod can trigger tuber formation in the late summer, we did not observe that early summer photoperiods triggered enhanced growth. While monoecious hydrilla is slow to form a canopy, its ability to grow laterally and cover the bottom sediments under low light conditions would benefit the plant in turbid waters. This plant is highly sensitive to several of the registered herbicides and treatment timing is important in preventing new tuber formation.