

Joint Annual Meeting

**61st Meeting of the
Aquatic Plant
Management Society**



**40th Meeting of the
Midsouth Aquatic Plant
Management Society**



Programs & Abstracts

**Riverside Hilton
New Orleans, Louisiana
In Person: July 12-14, 2021
Virtual: July 29, 2021**

Meeting Sponsors

The Aquatic Plant Management Society appreciates the generous support of the following meeting sponsors. Through their support and contributions, we can conduct a successful and enjoyable meeting.

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Committee Chairs

Awards	John Madsen
Bylaws and Resolutions	James Leary
Education and Outreach	Brett Hartis
Exhibits	Dean Jones
Finance	Andy Fuhrman
Legislative	Rob Richardson
Meeting Planning	Rob Richardson
Membership	Marc Bellaud
Nominating	Mark Heilman
Past President's Advisory Program	Mark Heilman
Publications	Ryan Thum
Regional Chapters	Jay Ferrell
Scholastic Endowment	Gray Turnage
Strategic Planning	Tom Warmuth
Student Affairs	Mark Heilman
Website	Sam Sardes
	Brett Hartis

Special Representatives

AERF	Carlton Layne
BASS	Jeremy Slade
CAST	Lyn Gettys
NALMS	Terry McNabb
RISE	Sam Barrick
Science Policy Director	Lee Van Wychen
Women in Aquatics	Amy Kay
WSSA	Robert Richardson

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The MidSouth Aquatic Plant Management Society (MSAPMS) is an organization of scientists, educators, students, resource managers, administrators, and concerned individuals interested in the management and study of aquatic plants in the MidSouth region. Membership reflects a diversity of federal, state, and local agencies; universities and colleges; corporations; and small businesses.

The mission of the MidSouth Aquatic Plant Management Society is to provide a common forum in which to exchange ideas and information concerning the management of aquatic plants.

Objectives:

- **Assist in promoting the management of nuisance aquatic plants**
- **Provide for the scientific advancement of members of the Society**
- **Encourage scientific research**
- **Promote university scholarships and other educational assistance**
- **Develop and extend public interest in aquatic plant sciences**

APMS Presidents and Meeting Sites

1961	T. Wayne Miller, Jr.	Fort Lauderdale, FL	1991	Joseph C. Joyce	Dearborn, MI
1962	T. Wayne Miller, Jr.	Fort Lauderdale, FL	1992	Randall K. Stocker	Daytona Beach, FL
1963	William Dryden	Tampa, FL	1993	Clarke Hudson	Charleston, SC
1964	Herbert J. Friedman	Tallahassee, FL	1994	S. Joseph Zolczynski	San Antonio, TX
1965	John W. Woods	Palm Beach, FL	1995	Steven J. de Kozlowski	Bellevue, WA
1966	Zeb Grant	Lakeland, FL	1996	Terence M. McNabb	Burlington, VT
1967	James D. Gorman	Fort Myers, FL	1997	Kurt D. Getsinger	Fort Myers, FL
1968	Robert D. Blackburn	Winter Park, FL	1998	Alison M. Fox	Memphis, TN
1969	Frank L. Wilson	West Palm Beach, FL	1999	David F. Spencer	Asheville, NC
1970	Paul R. Cohee	Huntsville, AL	2000	J. Lewis Decell	San Diego, CA
1971	Stanley C. Abramson	Tampa, FL	2001	Jim Schmidt	Minneapolis, MN
1972	Robert J. Gates	Miami Springs, FL	2002	David P. Tarver	Keystone, CO
1973	Brandt G. Watson	New Orleans, LA	2003	Richard M. Hinterman	Portland, ME
1974	Alva P. Burkhalter	Winter Park, FL	2004	Ken L. Manuel	Tampa, FL
1975	Luciano Val Guerra	San Antonio, TX	2005	Eric P. Barkemeyer	San Antonio, TX
1976	Ray A. Spirnock	Fort Lauderdale, FL	2006	Jeffrey D. Schardt	Portland, OR
1977	Robert W. Geiger	Minneapolis, MN	2007	Donald W. Doggett	Nashville, TN
1978	Donald V. Lee	Jacksonville, FL	2008	Jim Petta	Charleston, SC
1979	Julian J. Raynes	Chattanooga, TN	2009	Carlton Layne	Milwaukee, WI
1980	William N. Rushing	Sarasota, FL	2010	Greg MacDonald	Bonita Springs, FL
1981	Nelson Virden	Jackson, MS	2011	Linda S. Nelson	Baltimore, MD
1982	Roy L. Clark	Las Vegas, NV	2012	Tyler Koschnick	Salt Lake City, UT
1983	Emory E. McKeithen	Lake Buena Vista, FL	2013	Terry Goldsby	San Antonio, TX
1984	A. Leon Bates	Richmond, VA	2014	Michael D. Netherland	Savannah, GA
1985	Max C. McCowen	Vancouver, BC	2015	Cody Gray	Myrtle Beach, SC
1986	Lars W. J. Anderson	Sarasota, FL	2016	Rob Richardson	Grand Rapids, MI
1987	Dean F. Martin	Savannah, GA	2017	John D. Madsen	Daytona Beach, FL
1988	Richard D. Comes	New Orleans, LA	2018	John H. Rodgers, Jr.	Buffalo, NY
1989	Richard Couch	Scottsdale, AZ	2019	Craig Aguillard	San Diego, CA
1990	David L. Sutton	Mobile, AL	2020	Mark Heilman	<i>Canceled due to COVID-19</i>
			2021	Ryan Wersal	New Orleans, LA

APMS Award Recipients

Honorary Members

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” Guerra	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
Jim Schmidt	2016
Joseph C. Joyce	2017
Jeffrey D. Schardt	2017
David A. Issacs	2018
Vernon V. Vandiver	2018
Eric P. Barkemeyer	2019
Linda Nelson	2020

President’s 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
John Madsen, Mike Netherland	2016
Jason Ferrell	2017
Robert Blackburn	2018
Sherry Whittaker	2018
Eric P. Barkemeyer	2019
Dave Petty, Bill Torres, Rob Richardson	2020

APMS Award Recipients

Max McCowen Friendship Award

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 and smile.

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
Ken Manuel	2016
David Isaacs	2017
John Gardner	2018
William A. Ratajczyk	2019
Tom Warmuth	2020

T. Wayne Miller Distinguished Service Award

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.

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
Craig Aguillard	2016
Tommy Bowen	2017
Tyler Koschnick	2018
Robert J. Richardson	2019
Jeremy Slade	2020

Outstanding Graduate Student Award

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

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
Kyla Iwinski	Clemson University	2016
Alyssa Calomeni	Clemson University	2017
Andrew Howell	North Carolina State University	2018
Tyler Geer	Clemson University	2019
Gray Turnage	Mississippi State University	2020

APMS Award Recipients

Outstanding International Contribution Award

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

Deborah Hofstra	National Institute of Water & Atmospheric Research	2013
Paul Champion	National Institute of Water & Atmospheric Research	2016
John Clayton	National Institute of Water & Atmospheric Research	2017
Tony Dugdale	Agriculture Victoria	2018

Outstanding Journal of Aquatic Plant Management Article Award

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

James Johnson, Ray Newman	University of Minnesota	2012
Michael D. Netherland and LeeAnn Glomski	U.S. Army Corps of Engineers	2014
Greg Bugbee, M. Gibbons, and M.J. Wells	Connecticut Agricultural Experiment Station	2016
Justin Nawrocki, Robert Richardson and Steve Hoyle	North Carolina State University	2017
Ryan A. Thum, Syndell Parks, James N. McNair, Pam Tynning, Paul Hausler, Lindsay Chadderton, Andrew Tucker, and Anna Monfils	Montana State University	2018
Alyssa J. Calomeni, Ciera M. Kinley, Tyler D. Geer, Maas Hendrikse, and John H. Rodgers Jr	Clemson University	2019
Melaney Dunne and Raymond Newman	University of Minnesota	2020

Outstanding Research/Technical Contributor Award

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

Michael Netherland, Dean Jones, and Jeremy Slade	University of Florida	2010
Kurt Getsinger	U.S. Army Corps of Engineers	2011
Mark Heilman	SePRO Corporation	2013
John Rodgers	Clemson University	2015
Rob Richardson	North Carolina State University	2016
Ryan Thum	Montana State University	2017
Scott Nissen	Colorado State University	2018
John D. Madsen	Unites States Department of Agriculture	2019
Patrick Moran and the DRAAWP	Unites States Department of Agriculture	2020

APMS Graduate Student Research 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 APMS Graduate Student Research Grant. This \$40,000 academic grant, co-sponsored by APMS and the seven regional APMS chapters, provides funding 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
<i>The Indirect Effects of Sonar Application on Lake Food Webs</i>			
Katia Englehardt	University of Maryland	2001	\$40,000
<i>Controlling Non-native Submersed Aquatic Macrophyte Species in Maryland Reservoirs: Plant Competition Mediated by Selective Control</i>			
Susan Wilde	University of South Carolina	2005	\$40,000
<i>Investigating the Role of Invasive Aquatic Plants and Epiphytic Cyanobacteria on Expression of Avian Vacuolar Myelinopathy (AVM)</i>			
John Madsen and Ryan Wersal	Mississippi State University	2007	\$60,000
<i>The Seasonal Phenology, Ecology and Management of Parrotfeather [Myriophyllum aquaticum (Vellozo) Verdecourt]</i>			
Rob Richardson, Sarah True, Steve Hoyle	North Carolina State University	2010	\$40,000
<i>Monoecious Hydrilla: Phenology and Competition</i>			
Ryan Thum	Grand Valley State University	2012	\$40,000
<i>A Quantitative Genetics Approach to Identifying the Genetic Architecture of Herbicide Susceptibility, Tolerance, and Resistance in Hybrid Watermilfoils (Myriophyllum spicatum x sibiricum)</i>			
Scott Nissen	Colorado State University	2014	\$40,000
<i>Exploring the Physiological Basis of 2,4-D Tolerance in Northern Watermilfoil x Eurasian Watermilfoil Hybrids</i>			

Rob Richardson	North Carolina State University	2015	\$40,000
<i>Aspects of Monoecious Hydrilla Physiology and Response to Herbicide Combination Treatments</i>			
Christopher R. Mudge and Bradley T. Sartain	Louisiana State University	2016	\$40,000
<i>Exploring Alternative Giant Salvinia (Salvinia molesta D.S. Mitchell) Management Strategies</i>			
John Rodgers and Tyler Geer	Clemson University	2017	\$60,000
<i>Evaluation of Management Options for Nitellopsis obtusa (Desvaux in Loiseleur) J. Groves, (1919) (Starry Stonewort) in the United States</i>			
Ryan A. Thum and Greg M. Chorak	Montana State University	2018	\$40,000
<i>Identifying Eurasian and Hybrid Watermilfoil Gene Expression Differences in Response to Frequently Used Herbicides for Improved Adaptive Management</i>			
Rob Richardson and Jens Beets	North Carolina State University	2020	\$40,000
<i>Evaluation of Effect of Biotype on Biology and Response to Herbicides of Aquatic Macrophyte Species</i>			

Sustaining Members



Alligare, a global leader in post-patent herbicide solutions and vegetation management, serves clients in the aquatic, forestry, range/pasture, roadway, utility/pipeline, and railroad markets. As an ADAMA Company, Alligare is connected to one of the largest chemical supply chains in the world, giving our customers access to the best active ingredients available at the best pricing possible. Alligare's field sales team provides technical expertise, training and ongoing support for clients. Alligare makes Vegetation Management Simple!



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.



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.



Aquatic Vegetation Control, Inc. (AVC) is a Florida corporation founded in 1986 offering vegetation management and general environmental consulting services throughout the southeast. Since its establishment as an exotic/nuisance vegetation management company specializing in the control of invasive wetland, aquatic and upland species, AVC has broadened its scope of capabilities to include; certified lake management, fish stocking, re-vegetation, mitigation and restoration services, mitigation monitoring services, aquatic, roadside, forestry and utility vegetation management, and environmental/ecological consulting. <https://www.avcaquatic.com/>



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 is an aquatic and land management adjuvant manufacturer serving distributors nationally. Calling Vero Beach, Florida home for over 40 years Brewer manufactures a variety of surfactants for pesticide penetration and wetting, bonding, and drift control. Aquatics and land managers nationwide use our products to improve pesticide uptake, thereby increasing efficacy and reducing the chemical footprint in the natural environments they serve. A family business for over 4 decades, Brewer International continues to invest in product development and manufacturing innovation to serve its distribution partners with only the best value, highest-quality products available.



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. Clarke pioneers, develops, and delivers environmentally responsible mosquito control and aquatic services to help control nuisances, prevent disease, and create healthy waterways.



Compliance Services International (CSI) is a leading regulatory consultancy providing innovative solutions for organizations faced with regulatory and environmental challenges. CSI's experienced scientists and regulatory specialists in the USA and the EU provide innovative approaches to solving regulatory and environmental challenges – combining traditional sciences with developing technologies to deliver economically sensible and scientifically sound results.



Cygnets Enterprises, Inc.

Cygnets 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. Cygnets is proud of its reputation for outstanding service, friendly, knowledgeable staff and our unmatched support of the aquatics industry. Cygnets Enterprises is the only aquatic distributor at the Charter Gold Member level in the Aquatic Ecosystem Restoration Foundation (AERF). Please visit www.cygnetsenterprises.com.



Duke Energy “*Building a smarter energy future*”. Duke Energy (NYSE: DUK), a Fortune 150 company headquartered in Charlotte, N.C., is one of the largest energy-holding companies in the U.S. It employs 30,000 people and has an electric generating capacity of 51,000 megawatts through its regulated utilities, and 3,000 megawatts through its nonregulated Duke Energy Renewables unit. Duke Energy is transforming its customers’ experience, modernizing the energy grid, generating cleaner energy, and expanding natural gas infrastructure to create a smarter energy future for the people and communities it serves. More information about the company is available at duke-energy.com. Follow Duke Energy on Twitter, LinkedIn, Instagram and Facebook.



Lake Restoration, located in MN, has specialized in controlling pond weeds, lake weeds, and nuisance algae since 1977. Lake Restoration’s product line-up includes: Mizzen, a copper based algaecide, Spritflo and Dibrox herbicides, a variety of pond dyes and nutrient reducers. Lake Restoration also manufactures the TORMADA product application boat, Vitaflume floating fountains, the retractable Goose D-Fence system, and the patented LAKEMAID to eliminate lake weeds automatically. For more information, visit our website www.lakerestoration.com.



The **Lee County Hyacinth Control District** was formed by the Florida Legislature in June 1961 to 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.



Maxunitech is an integrated enterprise focusing on the Research and Development, production, sales of agrochemicals, and relevant intermediates and other fine chemicals. Established in 2000, under the principles of “people oriented, united for innovation and pursue excellence”, we have been researching and developing new products, solving commercial issues from the perspective of technology, and fulfilling enterprise value with value added for our clients.



Valent Corporation signed a formal agreement with **Nufarm Americas** giving them exclusive distributorship of its products. All of Valent’s Professional Products, including its aquatics products, Clipper and Tradewind, will now be sold by Nufarm. This allows Nufarm to offer a portfolio of 10 products labeled for aquatics. Nufarm provides a wide variety of products labeled for aquatics, both systemic and contact, that can be used selectively or broad spectrum depending on their use.



Nutrien Solutions is a full-service vegetation management company, providing innovative solutions and quality products for the aquatic plant management industry. The cornerstone of our success is our highly educated and trained field staff. With strong commitments to environmental stewardship, innovation, and technology, Nutrien Solutions provides customized programs tailored to specific locations throughout the U.S. We are the country’s leading vegetation management provider, and we’re excited to introduce you to everything Nutrien Solutions has to offer. Visit: NutrienAgSolutions.com/Specialty.



For 25 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



SOLitude Lake Management is an environmental firm committed to providing sustainable solutions that improve water quality, enhance beauty, preserve natural resources, educate communities and reduce our environmental footprint. SOLitude's team of Aquatic Biologists, Ecologists and Environmental Scientists specializes in the execution of customized lake, pond, wetland and fisheries management programs that include algae and aquatic weed control, water quality testing and restoration, nutrient remediation, vegetation studies and biological assessments for clients across the United States.



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.

UPL AQUATICS

UPL NA, Inc. is a premier supplier of crop protection products and technologies designed for the agricultural, specialty, fumigation and aquatic markets. UPL has manufactured aquatic herbicides and algacides for the management of lakes, ponds, rivers and irrigation canals for more than 30 years. These products are marketed as Aquathol®, Hydrothol®, AquaStrike®, Chinook®, Current®, Symmetry®, Cascade®, Teton®, and recently released Top Deck™. With a customer-centric focus, UPL is committed to providing product stewardship and technical support to ensure your plant management operation is successful. Visit us at: <https://www.upl-ltd.com/us>

Exhibitors

The Aquatic Plant Management Society thanks the following companies for exhibiting their products and services. This list was current when the Program was submitted for printing. Please visit the exhibit hall in the Gallery for all Exhibitors, including not-for-profit organizations.

Alligare, LLC
Davidson, North Carolina

Aquatic Control, Inc.
Seymour, Indiana

Brandt Consolidated, Inc.
Springfield, Illinois

Brewer International
Vero Beach, Florida

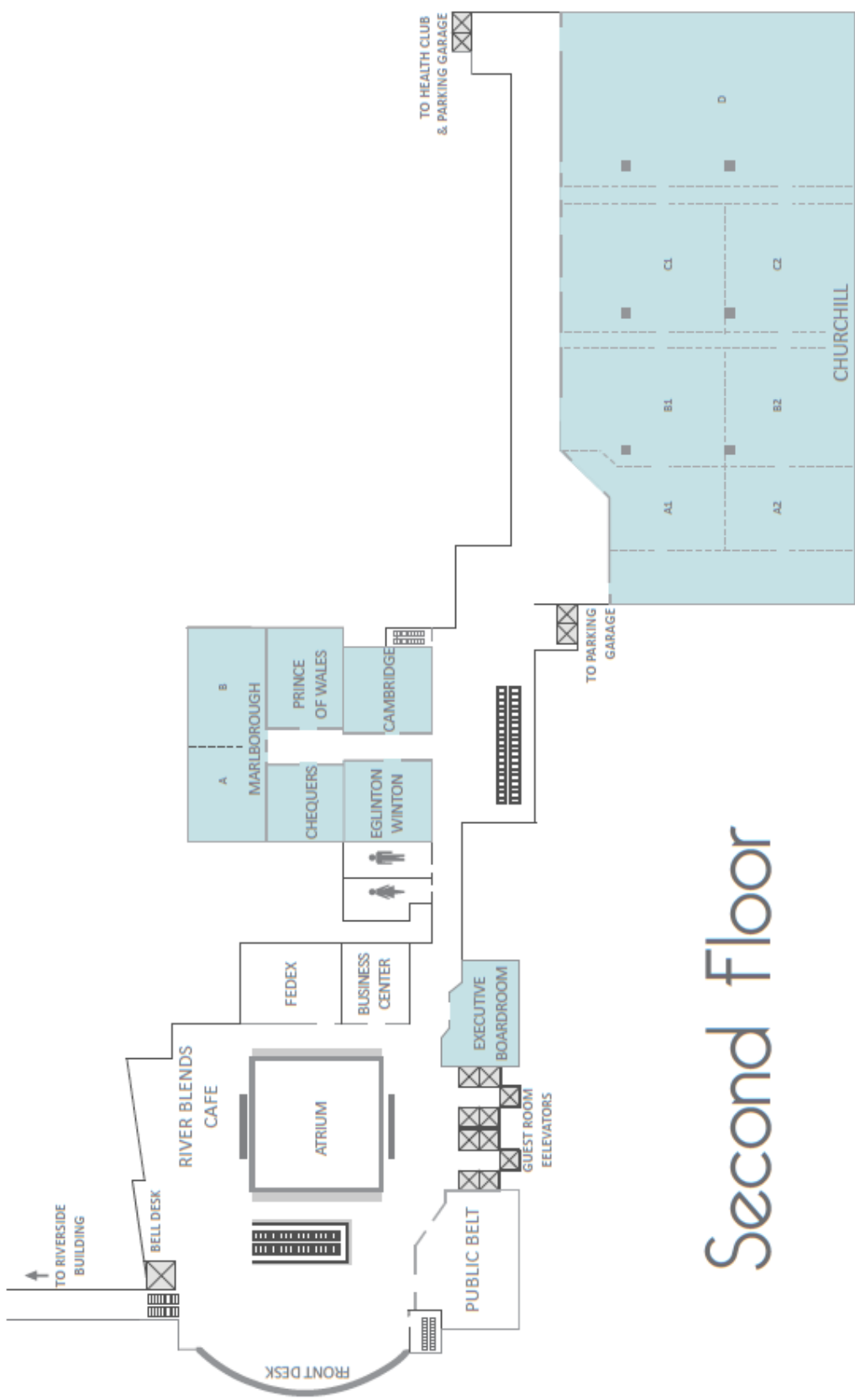
KeyColour
Phoenix, AZ

Nufarm Americas
Raleigh, North Carolina

Nutrien Solutions
Loveland, Colorado

SePRO
Carmel, Indiana

UPL NA Inc.
Exton, Pennsylvania



Second Floor

General Information and Events

Program Organization

The Agenda is organized by day and time. Presentations and abstracts are organized by title number within sections (oral, in-person, poster). 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. Most events will take place in the Churchill BC and Churchill D rooms. See the hotel site map on previous pages for event locations.

Name Badges

Your name badge is your ticket for all events 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, Poster Session Reception, and Awards Banquet at the meeting registration desk.

Meeting Registration Desk

The meeting registration desk will be in the Churchill Foyer on Monday July 12, from noon to 5:00 pm, and will continue from 7:30 am – 5:00 pm on Tuesday and Wednesday.

Exhibits

Exhibits will be open from noon Monday through 5:00pm Wednesday in Churchill BC.

Continental Breakfasts / Refreshment Breaks

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

Spur of the Moment Meeting Room

We have a room set up conferences. Check at the meeting registration desk to reserve.

Meet-and-Greet! *Monday, July 12, 5:00 pm to 6:00 pm, River Room, Riverside Building*

All registrants for the Annual Meeting are invited to mingle prior to the Presidents' Reception. Beverages and light snacks will be provided for this event.

President's Reception: *Monday, July 12, 6:00 pm to 9:00 pm, River Room, Riverside Building*

Join your APMS friends and colleagues at the Presidents' Reception 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.

Regional Chapters Presidents' Luncheon: *Tuesday, July 13, 11:30 am to 1:00 pm, Churchill A1*

Two representatives from each APMS regional chapter are invited to attend the Regional Chapter Presidents' Luncheon, provided by APMS sponsors. Regional Chapters Committee Chair Gray Turnage will be the moderator for discussions on aquatic plant management activities in each region. Please contact Gray by noon Monday, July 12 to confirm your attendance.

MSAPMS Awards: *Tuesday, July 13, 5:00 pm to 6:00 pm, Churchill D*

Past Presidents' Luncheon: *Wednesday, July 14, 11:30 am to 1:00 pm, Eglinton Winton*

All APMS Past Presidents are invited to attend the Past Presidents' Luncheon to provide insight into matters facing APMS and aquatic plant managers. Mark Heilman, Immediate Past President, will be the moderator. Please contact Mark by noon Monday, July 12 to confirm your attendance.

Women of Aquatics Luncheon: *Wednesday, July 14, 11:30 am to 1:00 pm, Churchill A1*

Amy Kay will host the APMS Women of Aquatics Luncheon to discuss opportunities for women in the field of aquatic plant management. Please contact Amy by noon Monday, July 12 to confirm your attendance.

Awards Reception/Banquet: *Wednesday, July 14, 6:00 pm to 10:00 pm, Riverboat City of New Orleans*

Registered delegates, guests and students are invited to the Awards Banquet aboard the Riverboat City of New Orleans. You can find the Riverboat outside the hotel. After dinner, we will recognize those who have served APMS, welcome new officers and directors. Our evening will conclude with a fund-raising raffle to support APMS student and other education initiatives.

Virtual Presentations: *Thursday, July 29, 8:00 am to 11:00 am*

This year we have additional talks as part of the virtual-only session. Web links will be forthcoming.

APMS/MSAPMS Annual Business Meetings: *Thursday, July 29, 11:00 am to noon*

All APMS and MSAPMS members are encouraged to attend the jointly-held Annual Business Meetings for Society updates as well as electing new Officers and Directors. Members will be provided a web link for the meeting.

Poster Session Reception:

This year's posters will be on demand and included in the virtual portion of the conference. We will email additional information and links. Please stay tuned for details. In lieu of a poster session at the in-person conference, please join us for the MSAPMS awards.

Events-at-a-Glance

Monday – July 12:

APMS Board of Directors Meeting (*Prince of Whales Room, 2nd floor*)
Exhibits Setup (*Churchill BC*)
Registration (*Churchill Foyer*)
Meet & Greet (*River Room, Riverside Building*)
Presidents' Reception (*River Room, Riverside Building*)

Tuesday – July 13:

Registration (*Churchill Foyer*)
Continental Breakfast (*Churchill BC*)
Exhibits (*Churchill BC*)
Session 1 (*Churchill D*)
Lunch on your own
Regional Chapters Presidents' Luncheon (*Churchill A1*)
Session 2 (*Churchill D*)
MidSouth APMS Regional Chapters Awards (*Churchill D*)

Wednesday – July 14:

Registration (*Churchill Foyer*)
Continental Breakfast (*Churchill BC*)
Exhibits (*Churchill BC*)
Session 3 (*Churchill D*)
Lunch on your own
Past Presidents' Luncheon (*Eglinton Winton*)
Women of Aquatics Luncheon (*Churchill A1*)
Session 4 (*Churchill D*)
APMS Awards Banquet Reception (*Riverboat City of New Orleans*)
APMS Awards Banquet (*Riverboat City of New Orleans*)

Thursday – July 29:

Virtual Talks
APMS/MSAPMS Business Meeting
Poster session
Post-conference APMS Board of Directors meeting

Agenda

Monday, July 12 (In Person)

Monday's Agenda-at-a-Glance

10am – 4pm	APMS Board of Directors Meeting (<i>Prince of Whales Room, 2nd floor</i>)
12pm – 5pm	Exhibits Setup (<i>Churchill BC</i>)
12pm – 5pm	Registration (<i>Churchill Foyer</i>)
6pm – 7pm	Meet & Greet (<i>River Room, Riverside Building</i>)
7pm – 9pm	Presidents' Reception (<i>River Room, Riverside Building</i>)

Tuesday, July 13 (In Person)

Tuesday's Agenda-at-a-Glance

8am – 5pm	Registration (<i>Churchill Foyer</i>)
730am-830am	Continental Breakfast (<i>Churchill BC</i>)
730am – 5pm	Exhibits (<i>Churchill BC</i>)
8am – 1130am	Session I (<i>Churchill D</i>)
1130am– 1pm	Lunch on your own
1130am– 1pm	Regional Chapters Presidents' Luncheon (<i>Churchill AI</i>)
1pm – 5pm	Session II (<i>Churchill D</i>)
5pm – 6pm	MidSouth APMS Regional Chapters Awards (<i>Churchill D</i>)

Session I – Opening Remarks, General Session

8:30 am - 11:30 am

Churchill D

Moderator: Ryan Wersal – APMS President Elect (*Minnesota State University, Mankato, Mankato, MN*)

08:30 AM Welcome and Opening Remarks

08:35 AM APMS Presidential Address.

Ryan Wersal

Minnesota State University, Mankato, Mankato, MN

08:45 AM MS-APMS Presidential Address

Wes Anderson

Alabama Power, Birmingham, AL

08:55 AM Louisiana: A History of *Salvinia molesta* Management. (1)

Daniel C. Hill

Louisiana Department of Wildlife and Fisheries, Baton Rouge, LA

09:15 AM An Integrated Approach to Control Aquatic Vegetation in Spring Bayou, Louisiana. (2)

Alexander Perret, Jody David, Brad Launey

Louisiana Department of Wildlife and Fisheries, Baton Rouge, LA

09:35 AM Nutrients Enhance the Negative Impact of an Invasive Floating Plant on Water Quality and a Submerged Macrophyte. (3)
Charles Wahl, Rodrigo Diaz, Michael Kaller
Louisiana State University, Baton Rouge, LA

09:55 AM Refreshment Break

10:30 AM Aquatic Ecosystem Restoration Foundation (AERF) Update. (4)
Carlton Layne
Aquatic Ecosystem Restoration Foundation, Flint, MI

10:50 AM Moving Pesticide Safety Education Online. (5)
Brett Bultemeier
University of Florida, Gainesville, FL

11:10 AM Glyphosate Education, Litigation, and Emerging Environmental Issues. (6)
Stephen F. Enloe, Brett Bultemeier
University of Florida, Gainesville, FL

Lunch

11:30 am – 1:00 pm

On your own

Regional chapters Presidents' Lunch (*Churchill A1*)

Session II – Student Presentations

1:00 pm – 4:30 pm

Churchill D

Moderator: James Leary (*University of Florida, Gainesville, FL*)

01:00 PM Do Species Invasion and Eutrophication Impact the Efficacy of Water Quality Improvement by Native Non-Weedy Wetland Plants? (7)
Andrew R. Sample
Mississippi State University, Starkville, MS

01:20 PM Short Term Effects of Florpyrauxifen-benzyl Alone and as Tank Mixtures on Invasive Aquatic Plants. (8)
Anna M. Sibley, Gray Turnage
Mississippi State University, Starkville, MS

01:40 PM Mosquitofern Response to Foliar Applications of Contact Herbicides. (9)
Garrett L. Ervin, Anna M. Sibley, Gray Turnage, Gary N. Ervin
Mississippi State University, Starkville, MS

02:00 PM Effects of Select Herbicides for Management of American Frogbit Grown in Mesocosms. (10)
Olivia L. Robinson, Gray Turnage, Adrián Lázaro-Lobo, Gary N. Ervin
Mississippi State University, Starkville, MS

02:20 PM Hydrilla Tuber Response to Herbicide Treatment under Simulated Drawdown Conditions. (11)
Taylor L. Darnell¹, William T. Haller¹, Candice M. Prince¹, Benjamin P. Sperry²
¹*University of Florida, Gainesville, FL*
²*US Army Corps of Engineers, Gainesville, FL*

02:40 PM Refreshment Break

03:10 PM Mechanisms of Triclopyr Non-Target Injury Following Basal Bark Treatments. (12)
Conrad A. Oberweger, Stephen F. Enloe, Patrick C. Wilson
University of Florida, Gainesville, FL

- 03:30 PM Endothall Translocation in *Elodea canadensis* and *Lagarosiphon major*. (13)**
Mirella F. Ortiz, Scott J. Nissen
Colorado State University, Fort Collins, CO
- 03:50 PM Native Aquatic Vegetation Management to Enhance Multiple-user Benefits of Southeastern Wetlands. (14)**
Adrián Lázaro-Lobo, Gray Turnage, Gary N. Ervin
Mississippi State University, Starkville, MS
- 04:10 PM Gene Expression Responses to 2,4-D Herbicide Treatment Differ Between Two Strains of Eurasian and Hybrid Watermilfoil. (15)**
Gregory M. Chorak, Jennifer Lachoweic, Gillian Reynolds, Ryan A. Thum
Montana State University, Bozeman, MT

MidSouth APMS Awards

5:00 pm – 6:00 pm
Churchill D

Wednesday, July 14 (In Person)

Wednesday's Agenda-at-a-Glance

8am – 5pm	Registration (<i>Churchill Foyer</i>)
730am-830am	Continental Breakfast (<i>Churchill BC</i>)
730am – 5pm	Exhibits (<i>Churchill BC</i>)
8am – 12pm	Session III (<i>Churchill D</i>)
1130am– 1pm	Lunch on your own
1130am– 1pm	Past Presidents' Luncheon (<i>Eglinton Winton</i>)
1130am– 1pm	Women of Aquatics Luncheon (<i>Churchill A1</i>)
1pm – 5pm	Session IV (<i>Churchill D</i>)
6pm – 7pm	APMS Awards Banquet Reception (<i>Riverboat City of New Orleans</i>)
7pm – 10pm	APMS Awards Banquet (<i>Riverboat City of New Orleans</i>)

Session III – General Session

8:30 am - 11:30 am
Churchill D

Moderator: Benjamin P. Sperry (*US Army Corps of Engineers, Gainesville, FL*)

- 08:30 AM Lab to Field: Developing Chemical Control Recommendations for Starry Stonewort. (16)**
Ryan M. Wersal
Minnesota State University, Mankato, Mankato, MN
- 08:50 AM Genetic Diversity and Geographic Origins of Invasive Yellow Floating Heart (*Nymphoides peltata*) in the United States. (17)**
Ryan A. Thum¹, Nathan E. Harms², Nicholas Tippery³, Katelin Killoy¹, Ashley Wolfe¹
¹*Montana State University, Bozeman, MT*
²*US Army Corps of Engineers, Vicksburg, MS*
³*University of Wisconsin-Whitewater, Whitewater, WI*
- 09:10 AM Management Strategies Utilizing Florpyrauxifen-Benzyl (ProcellaCOR®) for Control of Yellow Floating Heart in an Oklahoma Drinking Water Reservoir. (18)**
Mark A. Heilman¹, Andy R. Dzialowski², Scott H. Stoodley²
¹*SePRO Corporation, Carmel, IN*
²*Oklahoma State University, Stillwater, OK*
- 09:30 AM Limitations to Biomass Estimation for FAV Using NDVI Analysis of Satellite Acquisitions. (19)**
David L. Bubenheim, Greg Schlick, Vanessa Genovese
NASA Ames Research Center, Moffett Field, CA

09:50 AM Refreshment Break

10:10 AM Home-Built “Drone Boat” for Submersed Aquatic Herbicide Application. (20)
George Selden
University of Arkansas at Pine Bluff, Jonesboro, AR

10:30 AM Online Boater Led Check-In/Check-Out Alternative to In-Person Inspections: A COVID-19 Response Pilot. (21) Edgar A. Rudberg
CD3, General Benefit Corporation, Saint Paul, MN

10:50 AM Managing Eurasian Milfoil in the Pacific Northwest with ProcellaCOR Herbicide Technology. (22) Terry McNabb
Aquatechnex, LLC, Bellingham, WA

11:10 AM Building a Centralized Database of Watermilfoil Strain Geographic Distribution and Herbicide Response for Use in Management Decision Making. (23) Ryan A. Thum¹, Gregory M. Chorak¹, Ashley Wolfe¹, Raymond Newman²
¹Montana State University, Bozeman, MT
²University of Minnesota, St. Paul, MN

Lunch

11:30 am – 1:00 pm

On your own

Past Presidents’ Luncheon (*Eglinton Winton*)

Women of Aquatics Luncheon (*Churchill A1*)

Session IV – General Session

1:00 pm - 5:00 pm

Churchill D

Moderator: Christopher R. Mudge (*U.S. Army Engineer Research & Development Center, Baton Rouge, LA*)

01:00 PM Evaluation of Diquat for Control of Flowering Rush in High Water Exchange Scenarios. (24)
Bradley T. Sartain¹, Kurt D. Getsinger¹, Damian J. Walter²
¹US Army Corps of Engineers, Vicksburg, MS
²US Army Corps of Engineers, Walla Walla, WA

01:20 PM Adaptive Management of Flowering Rush. (25)
John D. Byrd, Jr.¹, John D. Madsen², Ryan M. Wersal³, Tera Guetter⁴, **Gray Turnage¹**
¹Mississippi State University, Starkville, MS
²USDA-ARS, Davis, CA
³Minnesota State University, Mankato, Mankato, MN
⁴Pelican River Watershed District, Detroit Lakes, MN

01:40 PM A Case Study Directed by Using the Holes in Scientific Knowledge to Inform Surface Water Management Practices. (26)
Sonja Wixom, Jason Lewis, Jeff Biggs, Tom Locke
PondMedics, Prosper, TX

02:00 PM Herbicide Spray Loss and Retention: Influence of Floating Plant Density, Carrier Volume and Adjuvants. (27)
Christopher R. Mudge¹, Benjamin P. Sperry², Kurt D. Getsinger³
¹US Army Corps of Engineers, Baton Rouge, LA
²US Army Corps of Engineers, Gainesville, FL
³US Army Corps of Engineers, Vicksburg, MS

02:20 PM Refreshment Break

- 02:40 PM Herbicide Activity Dynamics of Foliar Applications to Waterhyacinth. (28)**
Benjamin P. Sperry¹, Candice M. Prince², Jason Ferrell²
¹*US Army Corps of Engineers, Gainesville, FL*
²*University of Florida, Gainesville, FL*
- 03:00 PM Trials to Evaluate “Natural” Herbicides for Aquatic Weed Management. (29)**
Lyn A. Gettys
University of Florida, Davie, FL
- 03:20 PM Management of Old World climbing fern (*Lygodium microphyllum*) under varied flooding regimes. (30)**
Candice M. Prince¹, Stephen F. Enloe¹, James Leary¹, Jonathan Glueckert²
¹*University of Florida, Gainesville, FL*
²*University of Florida, Boynton Beach, FL*
- 03:40 PM Evaluating Subsurface Field Applications of ProcellaCOR® SC (a.i. florypyrauxifen-benzyl) for suppressing Hydrilla. (31)**
James Leary¹, Kelli Gladding¹, Jacob Thayer¹, Jonathan Glueckert¹, Benjamin P. Sperry²
¹*University of Florida, Gainesville, FL*
²*US Army Corps of Engineers, Gainesville, FL*

Thursday, July 29 (Virtual)

Thursday's Agenda-at-a-Glance

8am-11am	Virtual Presentations
11am – 12pm	APMS/MSAPMS Business Meeting
12pm	Annual Conference adjourns
12pm – 1pm	Lunch on your own
1pm – 5pm	Post-conference APMS Board of Directors meeting

Session V – General Session, APMS/MSAPMS Business Meetings

8:00 am - 12:00 pm

**Web link(s) for all virtual meetings will be provided before the virtual conference*

Moderator: Robert J. Richardson (*North Carolina State University, Raleigh, NC*)

08:00 AM Welcome and Opening Remarks

- 08:05 AM Development of Selective Control Options for Chemical Management of Cuban Bulrush. (32)**
Jackson Jablonski¹, Candice M. Prince¹, Stephen F. Enloe¹, Greg MacDonald¹, Benjamin P. Sperry²
¹*University of Florida, Gainesville, FL*
²*US Army Corps of Engineers, Starkville, MS*

- 08:20 AM Phenology and Starch Allocation Patterns of Cuban Bulrush (*Cyperus blepharoleptos*) Harvested from Field Locations. (33)**
Madeline M. Kjellesvig¹, Ryan M. Wersal¹, Gray Turnage²
¹*Minnesota State University, Mankato, Mankato, MN*
²*Mississippi State University, Starkville, MS*

- 08:35 AM Evaluating the Response of Invasive Flowering Rush (*Butomus umbellatus*) Cytotypes to Chemical Control Measures. (34)**
Jacob A. Hockensmith¹, Gray Turnage², Cory Shoemaker³
¹*Slippery Rock University, Poland, OH*
²*Mississippi State University, Starkville, MS*
³*Slippery Rock University, Slippery Rock, PA*

- 08:50 AM Littoral Physical, Chemical, and Biological Characteristics Determining Submersed Aquatic Vegetation Distribution in a Freshwater Reservoir. (35)**
Kara J. Foley, Ramon Leon, Robert J. Richardson
North Carolina State University, Raleigh, NC
- 09:05 AM Aquatic Macrophyte Communities in Five Sibley County (Minnesota) Lakes and the Factors that Affect Their Distribution. (36)**
Samuel A. Schmid, Ryan M. Wersal
Minnesota State University, Mankato, Mankato, MN
- 09:20 AM Break**
- 09:25 AM The Ecology of Submersed Aquatic Vegetation Communities under Management in Select Florida Lakes. (37)**
Jacob Thayer, James Leary, Candice M. Prince, Kelli Gladding
University of Florida, Gainesville, FL
- 09:40 AM Hybridization and invasiveness in Eurasian watermilfoil (*Myriophyllum spicatum*): is prioritizing hybrids in management justified? (38)**
Hannah K. Hoff, Ryan A. Thum
Montana State University, Bozeman, MT
- 09:55 AM Unmanned Aerial Application Systems for Aquatic Plant Control: case studies in North Carolina. (39)**
Andrew W. Howell¹, Tyler Harris², Robert J. Richardson²
¹*North Carolina State University, Pittsboro, NC*
²*North Carolina State University, Raleigh, NC*
- 10:10 AM Small-scale Efficacy Screenings of Florpyrauxifen-benzyl in Combination with Either Chelated Copper or Endothall for the Control Monoecious Hydrilla. (40)**
Erika J. Haug, Jens P. Beets, Robert J. Richardson
North Carolina State University, Raleigh, NC
- 10:25 AM Monitoring Monoecious Hydrilla in flowing water systems of North Carolina. (41)**
Jens P. Beets¹, Erika J. Haug¹, Robert J. Richardson¹, Benjamin P. Sperry², Tyler Harris¹
¹*North Carolina State University, Raleigh, NC*
²*US Army Corps of Engineers, Gainesville, FL*
- 10:40 AM *Amynothrips andersoni*: Evaluating a Potential Tool for Managing Alligatorweed in Temperate Climates. (42)**
Ian A. Knight, Nathan E. Harms
US Army Corps of Engineers, Vicksburg, MS
- 10:55 AM Break**
- 11:00 AM APMS/MSAPMS Joint Annual Business Meeting**

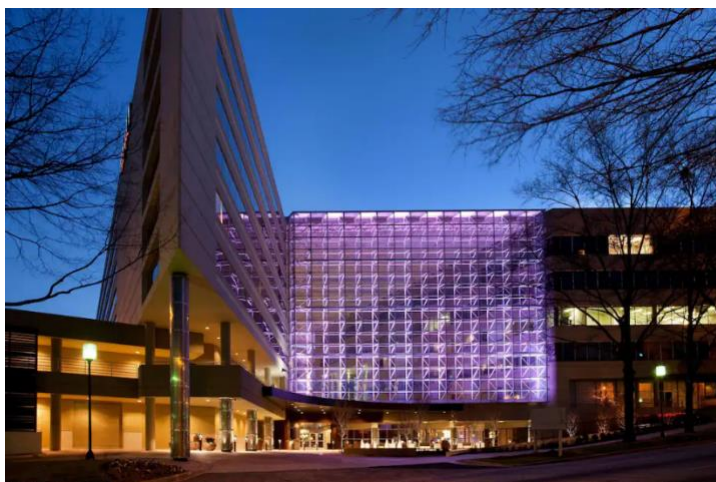
Poster Session

**Web link(s) will be provided before the virtual conference*

Evaluating the Long-term Effects of Aquatic Invasive Plant Management on Florida Plant Communities. (43)
Amy E. Kendig, Mark V. Hoyer, James Leary, S. Luke Flory, Candice M. Prince
University of Florida, Gainesville, FL

Regenerative Potential of Hydrilla Fragments Following Desiccation. (44)
Taylor L. Darnell¹, Candice M. Prince¹, Benjamin P. Sperry²
¹*University of Florida, Gainesville, FL*
²*US Army Corps of Engineers, Gainesville, FL*

**62nd Annual Meeting
Hyatt Regency Greenville
Greenville, SC
July 18-21, 2022**



Abstracts - General Sessions and Poster Session

Abstracts are listed by number in the program. Presenting author appears in **bold**.

ORAL (In Person)

Louisiana: A History of *Salvinia molesta* Management. (1) Daniel C. Hill

Louisiana Department of Wildlife and Fisheries, Baton Rouge, LA

The Louisiana Department of Wildlife and Fisheries is charged with controlling invasive and exotic nuisance aquatic vegetation to provide boating access for fishing, hunting and recreational interests. Our program employs a seek and destroy strategy to keep nuisance aquatic plants at the lowest feasible levels. Louisiana has a plethora of aquatic ecosystems. In fact, The Sportsman's Paradise is 17% water, with over 9,174 square miles of waterways. Giant salvinia (*Salvinia molesta*) was discovered in Toledo Bend in 1998. Since 2006, the Brazilian floating fern has spread to over 90 waterbodies and every aquatic habitat that Louisiana has to offer. Through years of research and field trials, LDWF has been heavily involved in the development of giant salvinia management strategies. Dozens of methods and approaches have been tested over the years, with varying degrees of success. This has provided a pool of effective options to be used in different situations, and also identified those that are not successful or not applicable in certain conditions.

An Integrated Approach to Control Aquatic Vegetation in Spring Bayou, Louisiana. (2) Alexander Perret, Jody David, Brad Launey

Louisiana Department of Wildlife and Fisheries, Baton Rouge, LA

Spring Bayou is a 2,718-acre complex of backwater lakes and tributaries in Louisiana with diverse habitat composed of flooded timber, including bald cypress (*Taxodium distichum*), black willow (*Salix nigra*), swamp privet (*Forestiera acuminata*), buttonbush (*Cephalanthus occidentalis*), and water elm (*Planera aquatic*). Although some channels were dredged in 1989 and 2009, the complex is relatively shallow, averaging 3-5 feet in depth. In 1994, hydrilla was discovered in Spring Bayou, and within two years the plant covered 75% of the water body. Drawdowns were conducted in 1996 and 1997, and numerous herbicide treatments were utilized with variable success. In 2006, hydrilla continued to cover approximately 75% of the lake. A total of 62,500 juvenile triploid grass carp (TGC) were stocked in the Spring Bayou complex between 2008 and 2015 as a biological control to reduce the spread of hydrilla. A portion of the TGC were implanted with transmitters and telemetry equipment was used to track their movements. Results from the telemetry study indicated that the TGC were moving throughout the complex, and the majority were not leaving the waterbody, even during high water events. Results from this long-term effort indicate that integrated management techniques, incorporating extensive stocking of triploid grass carp, resulted in considerable reductions in submersed vegetation throughout the Spring Bayou complex. Using the integrated management regime of chemical, biological and physical controls, LDWF biologists have been successful in improving boating access and recreational fishing opportunities in Spring Bayou.

Nutrients Enhance the Negative Impact of an Invasive Floating Plant on Water Quality and a Submerged Macrophyte. (3) Charles Wahl, Rodrigo Diaz, Michael Kaller
Louisiana State University, Baton Rouge, LA

Submerged macrophytes are an important component to the structure and function of freshwater ecosystems. Invasive free floating macrophytes can adversely impact native submerged macrophytes, and these impacts may be exacerbated by anthropogenic nutrient loading. Using a mesocosm study, we examined how the invasive macrophyte, giant salvinia (*Salvinia molesta*), affected water quality and biomass of a native submerged macrophyte, coontail (*Ceratophyllum demersum*), under salvinia cover treatments and nutrient additions, compared with control cover and nutrient treatments. Under high nutrients, giant salvinia growth rate was $\sim 1.0 \text{ g dry wt d}^{-1}$, which was 5-times greater than no nutrient addition. We found as giant salvinia grew and increased surface area, dissolved oxygen, pH, specific conductance, and light availability decreased. Additionally, the rate of change for these parameters were determined by nutrient availability. Coontail biomass was negatively affected by giant salvinia under increased nutrients, however, coontail persisted to the conclusion of the study, while being covered by a complete giant salvinia mat for three weeks. When nutrients were not added, changes to the environment due to giant salvinia were not statistically different from control treatments. Our results demonstrate how eutrophication of waterbodies enhances salvinia growth, which amplifies the rate of environmental impact. However, the ability of coontail to persist under a vegetative mat for weeks provides a timeframe to control giant salvinia while still retaining submerged macrophytes.

Aquatic Ecosystem Restoration Foundation (AERF) Update. (4) Carlton Layne
Aquatic Ecosystem Restoration Foundation, Flint, MI

Update on issues relevant to aquatic plant management.

Moving Pesticide Safety Education Online. (5) Brett Bultemeier
University of Florida, Gainesville, FL

Pesticide safety education, and to a large degree extension as a whole, are primarily based on in-person training events. Although this method still offers many advantages, there is no doubt that the increased reach of the virtual training space must be utilized. Many pesticide education programs had to adapt very quickly to move online during the COVID-19 pandemic. This presentation will provide some of the lessons learned and a few of the tools that have been adapted to successfully deliver training in a virtual environment.

Glyphosate Education, Litigation, and Emerging Environmental Issues. (6) Stephen F. Enloe, Brett Bultemeier
University of Florida, Gainesville, FL

Glyphosate is the most widely used herbicide in the United States and the world. For decades, university researchers, extension specialists and industry representatives alike have touted the herbicide as extremely safe, based upon numerous studies indicating an excellent toxicological profile. In 2015, this safety was brought into question when the International Agency for Research on Cancer (IARC) reclassified glyphosate as a probable carcinogen. Following the IARC decision, in 2017, the California Office of Environmental Health Hazard Assessment placed glyphosate on its Proposition 65 list of carcinogens. Subsequently, in 2018 and 2019, juries awarded over 2.3 billion dollars in three separate trials to plaintiffs who alleged glyphosate was the cause of their cancer. These and thousands of other lawsuits resulted in a recent class action settlement by Bayer in 2020 totaling over ten billion dollars. Although the EPA has not added restrictions to glyphosate labels, its recent draft biological assessment released in November has raised additional questions regarding endangered species. Due to these actions, many cities and counties in the United States have considered or implemented bans on glyphosate use. This has resulted in a tremendous need for a new approach to educating both herbicide applicators, government officials, and the general public on the controversy surrounding glyphosate. Additionally, despite no new EPA mandates to increase restrictions on glyphosate labels, there is a clear need for glyphosate alternatives for invasive plant management where it has been banned. This presentation will focus on how UF/IFAS is leading the effort to clarify what has transpired, present the science of glyphosate to a broad range of clientele, and provide glyphosate alternatives for invasive plant management based upon sound science.

Do Species Invasion and Eutrophication Impact the Efficacy of Water Quality Improvement by Native Non-Weedy Wetland Plants? (7) Andrew R. Sample
Mississippi State University, Starkville, MS

Increased nutrient inputs into the Mississippi River resulting from extensive agricultural activity and loss of wetlands in the Lower Mississippi Alluvial Valley can be mitigated via wetland restoration initiatives. The goal of this study is to improve these initiatives by evaluating nutrient removal associated with two regionally non-weedy emergent macrophyte species (*Juncus effusus* and *Schoenoplectus tabernaemontani*), and the degree to which that nutrient removal is altered by two common weedy emergent macrophyte species (*Typha latifolia* and *Phragmites australis*) and by eutrophication. This goal will be achieved by implementing a multi-year flow-through mesocosm study in which baseline nutrient removal conditions for each species will be established in the first year by measuring nutrient removal in a monoculture scenario, followed by simulated scenarios of species invasion (non-weedy and weedy mixed culture) in the second year and eutrophication (mixed culture and increased nitrogen concentration) in the third year. My hypotheses are that: 1) nitrogen removal efficiency as a proportion of plant uptake in monoculture mesocosms will differ from nitrogen removal efficiency in mixed species mesocosms and 2) nitrogen removal efficiency as a proportion of plant uptake by non-weedy species in mixed species mesocosms will differ under eutrophic conditions compared to under baseline nitrogen conditions. Nitrogen levels based on concentrations from previous studies of water quality in the region will be simulated using measured amounts of fertilizer. Plant growth data and water quality data will be collected at regular intervals during the growing season of each year of the study. Appropriate statistical analyses will be used to analyze effects of treatments (species and monoculture vs. mixture) on nitrogen removal from the water column by the different species. The results of this study may be useful for

managers of restoration and treatment wetlands regarding species selection for project design and for planning adaptive management strategies.

Short Term Effects of Florpyrauxifen-benzyl Alone and as Tank Mixtures on Invasive Aquatic

Plants. (8) Anna M. Sibley, Gray Turnage
Mississippi State University, Starkville, MS

Florpyrauxifen-benzyl (FPB) is a new herbicide in the auxinic class of herbicides (i.e., similar to 2, 4-D and triclopyr) that is registered for use in aquatic environments. FPB has shown good to excellent activity on invasive aquatic plant species like hydrilla (*Hydrilla verticillata*); however, effects of FPB on many free-floating (water hyacinth [*Eichhornia crassipes*], water lettuce [*Pistia stratiotes*], Cuban bulrush [*Oxycaryum cubense*]) and rooted (*Ludwigia grandiflora*) invasive plant species are still understudied. Additionally, there is little information available regarding herbicide tank mixtures that include FPB. The purpose of this project was to examine effects of high and low doses of FPB (58.2 and 29.1 g a.i. ha⁻¹) alone and as tank mixtures with high and low doses of penoxsulam (98.6 and 49.3 g a.i. ha⁻¹) and flumioxazin (4,147 and 2,0474 g a.i. ha⁻¹) on the aforementioned species. Herbicides were applied as foliar sprays to target species. Diluent water was buffered to a pH of 6.5 to 7.0 to prevent breakdown of flumioxazin. All herbicide solutions were applied at 378.5 L ha⁻¹ and included 0.5% v:v methylated seed oil as a surfactant. Cuban bulrush biomass was reduced 93 to 98% with high doses of FPB mixed with penoxsulam and reduced by 100% by all flumioxazin treatments when compared to reference plants at 8 weeks after treatment (WAT). Water hyacinth biomass was reduced 84 to 100% by all treatments except high doses of FPB. Water lettuce biomass was reduced 98% by high doses of FPB mixed with penoxsulam and reduced by 100% by all flumioxazin treatments when compared to reference plants. Aboveground water primrose biomass was reduced 70 to 100% by all treatments; however, belowground biomass was not affected by any treatment at 8 WAT when compared to reference plants. Long term effects of these treatments will be determined late summer 2021.

Mosquitofern Response to Foliar Applications of Contact Herbicides. (9) Garrett L. Ervin, Anna M.

Sibley, Gray Turnage, Gary N. Ervin
Mississippi State University, Starkville, MS

Mosquitofern (*Azolla caroliniana*) is a free-floating aquatic fern capable of covering waterbodies and outcompeting submersed macrophytes potentially leading to a loss of biodiversity. Limited evidence suggests that mosquitofern can be controlled with the contact herbicide diquat; however, peer review literature regarding effects of other contact herbicides labeled for use in aquatic environments on mosquitofern is lacking. The purpose of this work was to determine the effects of the contact herbicides flumioxazin (12 and 6 oz/ac), carfentrazone-ethyl (13.5 and 6.75 oz/ac), endothall (67 and 32 oz/ac), diquat (256 and 128 oz/ac), and copper (218 and 109 oz/ac) at 4 weeks after treatment (WAT) when compared to reference plants. This trial was initiated in late March 2021 and repeated 2 weeks later (early April). Treatments were administered as a foliar spray at a target diluent rate of 100 gal/ac; all herbicide treatments included a 1% v:v non-ionic surfactant. Diluent water was buffered to a pH range of 6.5 to 7.0 to prevent breakdown of PPO herbicides (flumioxazin and carfentrazone-ethyl). Each treatment was replicated 4 times. Biomass data was analyzed using a mixed-model ANOVA followed by a Fishers LSD test using treatment as a fixed effect and trial run as a random effect. At 4 WAT, flumioxazin (12 oz/ac), carfentrazone-ethyl (13.5 oz/ac), and diquat (256 and 128 oz/ac) treatments reduced mosquitofern

biomass by 84%, 88%, 99%, and 95% (respectively) compared to non-treated reference plants ($p < 0.0001$). To our knowledge, this is the only work to document mosquitofern biomass reduction by the PPO inhibiting herbicides flumioxazin and carfentrazone-ethyl. Diquat and flumioxazin have documented effects on other aquatic fern species (i.e., *Salvinia molesta*) suggesting that they may be useful for controlling other invasive aquatic fern species like *Azolla pinnata* and/or *Salvinia minima*. This work should be validated on field populations prior to operational use.

Effects of Select Herbicides for Management of American Frogbit Grown in Mesocosms. (10)

Olivia L. Robinson, Gray Turnage, Adrián Lázaro-Lobo, Gary N. Ervin
Mississippi State University, Starkville, MS

Limnobium spongia (frogbit) is a free-floating aquatic plant that can produce extensive floating mats that cause negative ecological, social, and economic impacts, which can have negative effects on aquatic fauna (i.e., dissolved oxygen depletion) and restrict waterbody access, navigation, and recreational usage by humans. Literature describing effective control measures for frogbit is minimal. Control efficacy of high and low doses of seven foliar applied herbicides (2,4-D, florypyrauxifen-benzyl, flumioxazin, glyphosate, imazamox, imazapyr, and triclopyr) were evaluated in a mesocosm trial conducted in the summer of 2018 and repeated in 2020. Both emergent and submersed frogbit biomass were reduced 97.8 to 100% by imazamox (0.56 and 1.11 kg a.i. Ha^{-1}) and imazapyr (0.42 and 0.84 kg a.i. Ha^{-1}) 8 weeks after treatment (WAT) compared to non-treated reference plants. None of the other herbicide treatments were different than the referent plants at 8 WAT in either year. However, 2,4-D (2.12 and 4.24 kg a.i. Ha^{-1}), flumioxazin (0.42 kg a.i. Ha^{-1}), and triclopyr (6.71 kg a.i. Ha^{-1}) had the same level of frogbit biomass reduction (79%) as the most efficacious herbicide treatments in at least one year. Future research should consider the efficacy of different herbicide combinations to control frogbit, as well as the role of diluent volume per unit area in providing frogbit control, especially with imazamox and imazapyr. Field studies also will be useful in determining whether these results translate to management of frogbit in natural settings.

Hydrilla Tuber Response to Herbicide Treatment Under Simulated Drawdown Conditions. (11)

Taylor L. Darnell¹, William T. Haller¹, Candice M. Prince¹, Benjamin P. Sperry²

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Hydrilla [*Hydrilla verticillata* (L.f.) Royle] is one of the most troublesome submersed aquatic weeds in the US. Management of hydrilla is difficult due to the formation and persistence of subterranean turions (tubers). Previous research indicates that hydrilla tubers can be controlled with herbicide applications made during drawdowns (dewatering of an aquatic system). However, further research is needed to develop management methods for drawdown situations. Consequently, a pond study was conducted to evaluate the efficacy of several herbicides registered for aquatic use on hydrilla tubers. The herbicides bispyribac-sodium, flumioxazin, florypyrauxifen-benzyl, imazamox, penoxsulam, and topramezone were applied at 0.5X, 1X, and 2X the maximum foliar use-rate to 11.4 L dishpans filled with sand/fertilizer containing 20 tubers per dishpan. The experiment was set up as a completely randomized design with four replications, a factorial arrangement of treatments (herbicide by rate), and included a nontreated control for reference. Dishpans were kept moist for five days after treatment until they were placed in ponds and allowed to grow for 18 weeks. At 18 weeks after treatment, aboveground biomass was

harvested, dried, and weighed. Florpyrauxifen-benzyl at 0.5X, and topramezone at either 0.5X or 1X were the only treatments that did not reduce hydrilla biomass from the control. Conversely, bispyribac-sodium, imazamox, and penoxsulam provided >93% hydrilla biomass reductions regardless of rate. Flumioxazin at any rate and florpyrauxifen-benzyl at 1X and 2X provided 53 to 87% hydrilla biomass reductions. Based on these data, the three ALS-inhibiting herbicides tested showed the greatest potential for successful hydrilla control in drawdown treatments. Ongoing research focuses on the use of the three ALS-inhibiting herbicides, applied at maximum foliar rate, for inhibition of hydrilla growth. Future research will investigate these treatments at operational scale as well as response of other hydrilla biotypes.

Mechanisms of Triclopyr Non-Target Injury Following Basal Bark Treatments. (12) Conrad A. Oberweger, Stephen F. Enloe, Patrick C. Wilson
University of Florida, Gainesville, FL

Triclopyr is used for woody plant control in Florida natural areas. Recently, an acid formulation (Trycera) was labeled for aquatic habitats and can be used for basal bark applications. However, flashback injury on non-target species in wetland environments has been reported. Two potential mechanisms of flashback include triclopyr root exudation and movement of triclopyr via flooding. To assess these pathways, two mesocosm studies were conducted over the summer and fall of 2020. Both studies utilized 16 (94-L) tubs, planted with *Schinus terebinthifolia*, *Celtis laevigata*, *Acer rubrum*, and *Cephalanthus occidentalis*. Sample wells were installed in each tub for water sampling. For study one, treatments included 1) basal oil only, 2) basal oil + triclopyr acid applied as Trycera herbicide (34 g ae/L), 3) basal oil + activated charcoal, and 4) basal oil + activated charcoal + triclopyr acid. The activated charcoal was layered 2.5 cm in depth across the entire surface of the tub just prior to treatment. For study two, treatments were similar, except flooding was applied instead of activated charcoal. Flooding was applied to a depth of 7.5 cm immediately following treatment and maintained for 21 days. Visual injury data and triclopyr analysis of water samples indicated triclopyr root exudation is very limited and not likely an issue. However, flooding can result in significant release of triclopyr into the water column with non-target damage to certain species. Analysis of surface water samples from flooded mesocosms revealed concentrations of triclopyr up to 3800 ug L⁻¹. Concentrations of triclopyr in the water column increased for up to 21 days after treatment and then began to decline. These findings can assist wetland managers in good triclopyr stewardship to prevent non-target injury.

Endothall Translocation in *Elodea canadensis* and *Lagarosiphon major*. (13) Mirella F. Ortiz, Scott J. Nissen
Colorado State University, Fort Collins, CO

There are two endothall formulations available for aquatic weed management, endothall dipotassium salt and endothall mono(N,N-dimethylalkalamine) salt. The amine formulation is generally two to three times more active than the dipotassium formulation and it is the only one labeled for *Elodea* control in the US, while in New Zealand the dipotassium salt formulation is labeled for *Lagarosiphon* control. These two species belong to the *Hydrocharitaceae* family. *Elodea* is a native species, while *Lagarosiphon* is an invasive species in Australia, New Zealand, and parts of Europe. *Lagarosiphon* is not present in the US at this time. Although endothall is considered a contact herbicide, studies have shown that it has systemic

activity. Therefore, the goals of this research were to compare endothall absorption rate and evaluate endothall translocation from shoots to roots in *Elodea* and *Lagarosiphon*.

Native Aquatic Vegetation Management to Enhance Multiple-user Benefits of Southeastern Wetlands. (14) **Adrián Lázaro-Lobo**, Gray Turnage, Gary N. Ervin
Mississippi State University, Starkville, MS

This project determined optimally effective methods of managing native aquatic plants that cause ecological, economic, and social problems in southeastern United States. The target nuisance species were *Nelumbo lutea* (American lotus), *Nymphaea odorata* (white water lily), and *Brasenia schreberi* (water shield). These species have floating foliage which can shade out submersed plants and algae and lead to decreased dissolved oxygen levels, which in turn can negatively affect aquatic fauna. They can also restrict human recreational activities of waterbodies. Additionally, allelopathy has been documented in white water lily and water shield, suggesting that these species could chemically suppress neighboring plant growth. Few methods are currently known that allow the control of such problematic species. We conducted mesocosm trials (i.e., tank experiments) to determine the potential of seven herbicides labeled for use in aquatic systems to reduce abundance of our target species under controlled conditions. Each herbicide was tested at a high and low concentration (maximum label rate and half of the maximum rate, respectively). Three of the tested herbicides (glyphosate, imazamox, and florypyrauxifen-benzyl) provided suppression of two of our three target species (white water lily and water shield). Then, we carried out field trials at Sam D. Hamilton Noxubee National Wildlife Refuge using the above-mentioned herbicides to determine which approaches work best in a field setting. We found that the three herbicides examined in the field trials (at high and low dosages) resulted in long term (52 weeks after treatment (WAT)) suppression of the water lily and water shield. However, the abundance of American lotus was generally increased at 52 WAT, likely because of a mismatch in application timing and peak leaf emergence for lotus. Additionally, the reduction of white water lily and water shield by herbicides might have reduced competition thereby favoring higher abundance of lotus.

Gene Expression Responses to 2,4-D Herbicide Treatment Differ Between Two Strains of Eurasian and Hybrid Watermilfoil. (15) **Gregory M. Chorak**, Jennifer Lachoweic, Gillian Reynolds, Ryan A. Thum
Montana State University, Bozeman, MT

Aquatic plant managers frequently treat Eurasian watermilfoil (*Myriophyllum spicatum* L.; EWM) and hybrid watermilfoil (*Myriophyllum spicatum* L. x *Myriophyllum sibiricum* Komarov) with the same management strategy. However, different genotypes of the two taxa have been shown to differ in their growth rates in control and herbicide environments. The genetic mechanism(s) of growth and herbicide response is likely the result of many genes and their levels of expression. RNA-Seq is a method to quantify the expression levels of all genes actively being used by an organism in a set of conditions, and is therefore a promising approach to identify mechanisms associated with growth rates in herbicide that are a result of gene expression differences between individuals. In this project we focused on the molecular response of Eurasian and hybrid watermilfoil to the commonly used herbicide 2,4-dichlorophenoxyacetic acid (2,4-D). We compared gene expression differences between control and 500ppb 2,4-D treated plants at several times after treatment for one hybrid and one EWM genotype known to exhibit differing growth rates in control and 2,4-D treatment environments. We found that the

molecular response of the EWM genotype to 500ppb 2,4-D treatment was much stronger than the hybrid genotype, indicated by a greater change in gene expression at all time points after treatment. Further, we found a similar response pattern in the genes known to be induced during 2,4-D treatment. (i.e. lower in hybrid; higher in EWM). This suggests that this genotype of hybrid watermilfoil is less affected by 500ppb 2,4-D treatment than the EWM genotype, and future studies should investigate if this is a taxon specific response, or a genotype level response related to growth rates. While more work is needed, studies like this may facilitate the development of rapid screens for watermilfoil 2,4-D response to inform treatment decisions.

Lab to Field: Developing Chemical Control Recommendations for Starry Stonewort. (16) Ryan M. Wersal

Minnesota State University, Mankato, Mankato, MN

Currently, much of the management of starry stonewort has been conducted using copper products, however there has been little documentation as to which formulation of copper may be more effective. Additionally, there have been limited attempts to evaluate herbicides as a management tool for starry stonewort. Small-scale trials showed that copper formulation did not impact efficacy on starry stonewort. All three formulations tested (copper ethanolamine complex, emulsified copper ethanolamine complex, and copper ethylenediamine) performed similarly and offered >60% biomass reduction depending upon treatment concentration. Diquat and products containing diquat were also efficacious on starry stonewort. Sensitivity to aquatic pesticides ranges from star duckweed < elodea < coontail < starry stonewort < wild celery based on data from small-scale trials. Under field conditions in Lake Koronis, MN copper was more effective at reducing aboveground biomass of starry stonewort, though bulbil densities were not reduced and increased from pretreatment sampling to 8 WAT. Diquat was not efficacious under field conditions and residue analysis and subsequent modeling indicated the half-life was <2 h among all treated plots. Assuming the target concentration of 0.37 mg/L was achieved shortly after application, 52% of the diquat was lost by 1 HAT and 98% lost by 6 HAT. Water exchange studies need to be conducted in areas of starry stonewort management to model exchange in order to better estimate pesticide half-lives. Research should be conducted to determine optimal timing of applications, biomass effects on copper efficacy (mass balance approach), and the outcomes of multiple applications per starry site per season. Effective management can only be obtained by having a thorough knowledge of starry stonewort phenology, especially bulbil production.

Genetic Diversity and Geographic Origins of Invasive Yellow Floating Heart (*Nymphoides peltata*) in the United States. (17) Ryan A. Thum¹, Nathan E. Harms², Nicholas Tippery³, Katelin Killoy¹, Ashley Wolfe¹

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²US Army Corps of Engineers, Vicksburg, MS

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Yellow floating heart (*Nymphoides peltata*) is an introduced floating-leaved aquatic plant native to Europe and Asia. The USDA-APHIS Weed Risk Assessment found a high likelihood that yellow floating heart could become a serious invader, and it is now distributed across much of the US. Little is known about the relative importance of vegetative versus sexual reproduction in its local persistence and spread across the US. In addition, although an assessment concluded that it would be a good candidate for

biological control, it is currently unclear where searches for potential control agents should be conducted in the native range. Here, we collected data from ten microsatellite markers on over 200 yellow floating heart plants collected from the US and the Eurasian native range in order to determine clonal versus sexual reproduction, and to identify the geographic origins of US infestations. Plants in the US were most similar genetically to collections from Europe, which suggests that biological control surveys should focus efforts there. Further, we found evidence for both vegetative and sexual reproduction in the US. One multilocus microsatellite genotype (clone) was widely distributed across the US, and two other clones were found in multiple southern and eastern US states. The wide geographic distributions of these clones indicate dispersal of vegetative fragments among water bodies and/or multiple introductions from the same source or stock (e.g., water garden trade). We found a single clone in our samples for the majority of US populations (66%), indicating a preponderance of local asexual reproduction. However, several local populations had multiple clones, which provides some evidence for localized sexual reproduction. Aquatic plant scientists and managers should consider this genetic diversity when developing control methods to determine whether efficacy of specific tactics differ among distinct genotypes.

Management Strategies Utilizing Florpyrauxifen-Benzyl (ProcellaCOR®) for Control of Yellow Floating Heart in an Oklahoma Drinking Water Reservoir. (18) Mark A. Heilman¹, Andy R.

Dzialowski², Scott H. Stoodley²

¹SePRO Corporation, Carmel, IN

²Oklahoma State University, Stillwater, OK

Lake Carl Blackwell is a 3,370-acre reservoir constructed in 1937 that serves as a drinking water supply for Oklahoma State University. The invasive floating-leaved aquatic plant, yellow floating heart (*Nymphoides peltata* or YFH), was confirmed in the reservoir by University personnel in 2014. In 2019, a management program was initiated by the University with the newly-registered aquatic herbicide, ProcellaCOR (a.i., florpyrauxifen-benzyl). On July 9, 2019, initial applications of ProcellaCOR SC were made to multiple YFH-infested sites totaling 55 acres. Applications were made via airboat utilizing an in-water injection strategy targeting 3 Prescription Dose Units (PDU) of the SC formulation per acre-foot ($\sim 29 \mu\text{g ai L}^{-1}$). Efficacy was assessed quantitatively using a combination of available satellite imagery and collection of high-resolution aerial photography using an Unmanned Aerial System (UAS or aerial drone). By three weeks post application, YFH coverage decreased 93% in targeted areas. Water quality monitoring documented minimal immediate impact of the ProcellaCOR applications on water quality and improvement in dissolved oxygen following YFH control. Minimal recovery was observed in July 2020, 1 year after the 2019 applications. However, YFH persisted in shallow areas, commonly with flooded dead timber, that could not be directly accessed by airboat and with projected minimal mixing with more open-water treated areas. Despite pandemic disruption, an October 2020 treatment targeted some additional YFH areas. Plans were also initiated to conduct UAS herbicide applications targeting water within low-access, remaining areas of the infestation in early summer 2021. The presentation will summarize multiple seasons of monitoring and assessment results for YFH control efforts on the reservoir including design and early implementation of planned 2021 UAS applications.

Limitations to Biomass Estimation for FAV Using NDVI Analysis of Satellite Acquisitions. (19)

David L. Bubenheim, Greg Schlick, Vanessa Genovese

NASA Ames Research Center, Moffett Field, CA

The distribution and standing biomass (mass per unit area) of Floating Aquatic Vegetation (FAV) provide assessment metrics for productivity in aquatic vegetative communities. Remote sensing data has been used to estimate standing biomass in various ecosystems using vegetation indices, particularly the normalized difference vegetation index (NDVI), comparing the relative strength of radiation absorbance and reflectance of vegetation in specific wavebands. Obstacles to estimating vegetation biomass using NDVI reported are related to diversity of the vegetation community and high-density saturation. We evaluate the potential for using NDVI derived estimates for FAV biomass in the California Delta. We focus on patches of predominantly single species and compare biomass estimates for specific patches with measurement of total biomass and partitioning within the vegetation canopy. Using Landsat satellite acquisitions, biomass estimates are made for individual pixels and vegetation samples were collected from those same pixels. Focus on patches of predominantly single FAV species resulted in successful estimation of standing biomass beyond that previously reported in other ecosystems. A saturation response for the estimations was observed, however, with a much higher threshold than previously reported for diverse population aquatic ecosystems. We discuss the likely cause for the saturation phenomenon and potential improvement utilizing altered spectral indices possible with higher spectral resolution from satellites carrying higher waveband multispectral and hyperspectral instruments.

Home-Built “Drone Boat” for Submersed Aquatic Herbicide Application. (20) George Selden

University of Arkansas at Pine Bluff, Jonesboro, AR

One of the most effective techniques for treating submersed nuisance aquatic vegetation is by using boat mounted, weighted trailing hoses to deliver herbicide into the weed bed. This ensures delivery of the herbicide to the target plants and can maximize both concentration and exposure time. For many owners of small ponds (2 acres or less), they are likely to try and treat the vegetation themselves, rather than have it performed by professionals. Using a commercially available fishing trolling motor, and components available at local big box hardware and irrigation supply stores, for less than \$2000, I was able to construct a “drone boat” capable of treating submersed aquatic vegetation. It is hoped that by demonstrating the ease with which this type of equipment can be constructed and used, owners of small ponds might be able more effectively treat submersed vegetation problems and maximize their enjoyment of the pond.

Online Boater Led Check-In/Check-Out Alternative to In-Person Inspections: A COVID-19 Response Pilot. (21) Edgar A. Rudberg

CD3, General Benefit Corporation, Saint Paul, MN

Preventing and containing the spread of aquatic invasive plants results in huge economic savings. Due to the high cost of high pressure, heated water decontamination, reducing the spread of aquatic invasive plants often relies upon the adoption of best management practices at the individual level. The adoption of these behaviors is especially needed during a pandemic where boating activity has dramatically increased while boat inspections have decreased. This presentation will outline a pilot project in

Minnesota in adopting a digital alternative to in-person inspections. In addition, the presentation will go over the biological efficacy of doing so.

Managing Eurasian Milfoil in the Pacific Northwest with ProcellaCOR Herbicide Technology. (22)

Terry McNabb

Aquatechnex, LLC, Bellingham, WA

Eurasian Milfoil (*Myriophyllum spicatum*) has been one of the dominate invasive aquatic weeds in the Pacific Northwest since the 1980's. The Columbia River system and many of it's tributaries including the Pend Oreille River/Lake system in north Idaho and the Clark Fork River in Montana. From there it has spread to many of the lakes throughout the region, primarily on boat trailers. In addition to severely impacting beneficial uses such as recreation, irrigation and power generation, these monoculture beds have had a significant impact on salmonid species. The littoral areas of the lake rivers and lake generally used for refuge for downstream migrating young have dense growths of milfoil that alter water chemistry parameters important to these species. Fluroxypyr-fen-benzyl or ProcellaCOR is a new reduced risk classification herbicide registered by the US EPA in February of 2018 and became available on the Washington State NPDES permit in the summer of 2019. This technology has the fastest plant accumulation factor of any systemic aquatic herbicide and has proven to be effective in high water exchange environments. This talk will provide background and present five case studies of operational use against both Eurasian and Hybrid Milfoils in Washington, Montana and Idaho waters. It will also provide a case study of a treatment on Lake Osoyoos that straddles the US/Canadian Border. ProcellaCOR is currently in the registration process in Canada and there is a Research Authorization for field use in the summer of 2021 in Canadian Waters.

Building a Centralized Database of Watermilfoil Strain Geographic Distribution and Herbicide Response for Use in Management Decision Making. (23) Ryan A. Thum¹, Gregory M. Chorak¹,

Ashley Wolfe¹, Raymond Newman²

¹Montana State University, Bozeman, MT

²University of Minnesota, St. Paul, MN

The COVID-19 pandemic has brought to light the importance of identifying and tracking 'variants' in real time. Similarly, aquatic plant managers increasingly recognize that Eurasian watermilfoil (including hybrids with native northern watermilfoil) is genetically diverse, and that strains can differ in their growth, spread, impacts, and herbicide response. A practical challenge for Eurasian watermilfoil management is developing efficient and effective methods to predict how a specific watermilfoil population will respond to a proposed control tactic (e.g., a specific herbicide) before implementing management. Our approach to this problem entails using genetic techniques to predict herbicide response, and our vision for developing genetic tools to inform management decisions includes a centralized, interactive database of watermilfoil strain geographic distribution and herbicide response to inform management decisions. For example, the identification of herbicide resistant strains, and the locations in which they are found, can be used to inform the choice of herbicide for watermilfoil control in different lakes. This talk will illustrate four key components of building such a database: 1) developing a standardized panel of molecular markers to distinguish and track strains in space and time, 2) criteria for prioritizing strains for herbicide response testing, 3) developing accurate and efficient bioassays for

herbicide response testing, and 4) automated integration of new genetic information that interfaces with a user-facing, interactive dashboard.

Evaluation of Diquat for Control of Flowering Rush in High Water Exchange Scenarios. (24)

Bradley T. Sartain¹, Kurt D. Getsinger¹, Damian J. Walter²

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In 2019 and 2020, field trials evaluated water exchange processes and management of flowering rush within McNary Dam and Reservoir in eastern Washington State. Diquat herbicide (Reward) and rhodamine WT dye were applied simultaneously to a 1.7 ha plot infested with emergent and submersed growth flowering rush. Dye readings were measured from multiple sampling points at specific time intervals within the plot to determine dye half-life. Dye half-lives represented *in-situ* whole plot water exchange processes occurring at the time of herbicide treatment and varied from 1.8 to 0.5 hours in 2019 and 2020, respectively. Post-treatment vegetation surveys in 2019 documented significant herbicide injury to flowering rush shoots 4 weeks after treatment (WAT) and a 40% decrease in flowering rush frequency of occurrence by 8 WAT. At 52 WAT, minimal emergent flowering rush was observed within the plot; however, flowering rush frequency of occurrence remained =90%. A follow up diquat treatment in 2020 provided results comparable to the 2019 treatment. Pending the results of the 104 WAT vegetation assessment a potential third diquat treatment is scheduled for July 2022. Utilizing water exchange data collected from these field demonstrations, two growth chamber studies were conducted to evaluate diquat treatments (0.0, 0.370 and 0.190 mg L⁻¹) across three exposure times (60, 30, and 15 minutes) for effectively controlling flowering rush. At the conclusion of each four week chamber study, viable above- and below-ground biomass was harvested, sorted, and number of rhizome buds per pot were recorded. Biomass and rhizome bud data were subjected to a one-way ANOVA and treatment means were separated using a Tukey's HSD test at p=0.05 significance level. Preliminary results for each study indicates that diquat treatments significantly reduced flowering rush shoot biomass (=87%) and belowground biomass (=42%) when compared to the non-treated reference at 4WAT.

Adaptive Management of Flowering Rush. (25) John D. Byrd, Jr.¹, John D. Madsen², Ryan M. Wersal³, Tera Guetter⁴, **Gray Turnage¹**

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Aquatic resource managers have limited resources to combat aquatic invasive plant species (AIS), thus methodologies that control AIS with minimal resources are desirable. One such AIS, flowering rush, is spreading across the northern U.S. and southern Canada. Flowering rush relies on vegetative reproduction (primarily through rhizome buds) to colonize new sites. Operational management in Detroit Lakes, MN found two submersed diquat (0.37 ppm) applications per growing season reduced flowering rush biomass and bud density. However, as recent invaders arrived in the system (i.e. Zebra mussels) there were limited resources to address both species. Research was undertaken to determine if flowering rush could be controlled by single diquat applications (rather than two) in sites of low flowering rush prevalence. Treatment sites were designated as having very-low, low, or high flowering rush prevalence

(measured as percent frequency) with each receiving zero, one, or two diquat treatments, respectively. When compared to non-treated reference sites, flowering rush prevalence, biomass, and bud density in low prevalence sites did not increase after two years of single diquat applications while prevalence declined 10 to 12% and biomass and bud density remained constant in high prevalence sites. Total area infested by high prevalence levels of flowering rush declined 14.4% even though total area infested increased during this study suggesting that adaptive management was sufficient to convert high prevalence sites to low prevalence sites. At peak infestation (2016), over 128 ha (316 ac) of flowering rush were being managed while in 2020 only 8 ha (20 ac) of flowering rush needed herbicide treatment. This adaptive strategy used 25 to 34% less herbicide than previous strategies while not sacrificing flowering rush management goals and allowing resource managers to allocate resources elsewhere.

A Case Study Directed by Using the Holes in Scientific Knowledge to Inform Surface Water Management Practices. (26) **Sonja Wixom**, Jason Lewis, Jeff Biggs, Tom Locke
PondMedics, Prosper, TX

The use of Nanobubbles in agricultural settings has been widely studied and used to create favorable results such as increased germination rates (Ahmed et al. 2018), controlling biofouling in irrigation settings (Xiao et al. 2020), and improved soil aeration (Baram, Evans, Berezkin, and Ben-Hur, 2021). Developments in the applications of use for Nanobubbles has been so rapid that Forbes has featured it in a few articles such as 'On Tap For 2021: Nanobubbles, Thermal Batteries, And More' (Kobayashi-Solomon 2021) where it is boasted as new technology to watch in 2021. However, the implementation, successes, and failures of Nanobubbles in surface water management are still relatively unknown. This case-study features a 30-day study of nanobubbles effect on dissolved oxygen, pH, and oxidation-reduction potential of multiple ponds in the North Central region of Texas. This case-study is designed to help confirm some management practices claims to be used in the present, identify further unknowns, and to illuminate where continuing research should be directed.

Herbicide Spray Loss and Retention: Influence of Floating Plant Density, Carrier Volume and Adjuvants. (27) **Christopher R. Mudge**¹, Benjamin P. Sperry², Kurt D. Getsinger³

¹US Army Corps of Engineers, Baton Rouge, LA

²US Army Corps of Engineers, Gainesville, FL

³US Army Corps of Engineers, Vicksburg, MS

Floating and emergent plants have been managed with foliar-applied herbicides for decades. However, little is known about aqueous spray deposition levels, or spray loss, following treatment. Therefore, mesocosm experiments were conducted in Baton Rouge, LA and Gainesville, FL in 2020 to evaluate the effect of floating plant density, carrier volume, and adjuvant type on spray solution losses to the water column using a tracer dye as an herbicide surrogate. In the first experiment, in-water rhodamine water tracer (RWT) dye concentrations were quantified after foliar treatment at a carrier volume of 100 gallons per acre (GPA) to water hyacinth (*Eichhornia crassipes*), water lettuce (*Pistia stratiotes*), or giant salvinia (*Salvinia molesta*) populations equivalent to 0, 25, 50, and 100 percent area covered (PAC). Spray loss to the water column decreased with increased PAC regardless of species; however, each species exhibited a unique relationship between density and percent spray loss. The plant material required to result in 50% spray loss (ED₅₀) was 32, 62, and 55 PAC for water hyacinth, water lettuce, and giant salvinia, respectively. Greater ED₅₀ estimates in water lettuce and giant salvinia compared to

waterhyacinth were hypothesized to be due to differences in plant architecture and leaf morphology. However, at the highest plant densities (100 PAC), water hyacinth and water lettuce resulted in 20 to 25% spray loss, whereas giant salvinia resulted in only 10% loss. In the second experiment, no differences in spray retention were observed among nine commonly used adjuvants tested when applied to water hyacinth at 100 GPA. In the final trial, as carrier volume increased from 10 to 200 GPA, spray retention decreased. However, waterhyacinth was most sensitive to increased spray loss from greater carrier volume, whereas spray loss in giant salvinia and water lettuce was not as extreme under greater volumes. Data generated in these mesocosm experiments will be used to refine further research under field conditions and ultimately aid in the development of best management practices to optimize foliar herbicide applications.

Herbicide Activity Dynamics of Foliar Applications to Waterhyacinth. (28) Benjamin P. Sperry¹, Candice M. Prince², Jason Ferrell²

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Experiments conducted from 2019 to 2021 investigated foliar application parameter effects on glyphosate, diquat, and 2,4-D activity on waterhyacinth (*Eichhornia crassipes*). Each herbicide was applied at a consistent rate using carrier volumes of 187, 467, or 935 L ha⁻¹. Furthermore, each carrier volume was applied using the following spray patterns: conventional stream, conventional cone, adjustable cone, or drizzle stream. Waterhyacinth control and biomass reduction from 2,4-D treatments was greatest in applications utilizing 187 L ha⁻¹ carrier volume and either cone-type spray pattern. Conversely, waterhyacinth control from diquat was not affected by carrier volume or spray pattern. However, glyphosate activity was significantly dependent on carrier volume resulting in 55, 82, and 97% biomass reduction from treatment at 935, 467, and 187 L ha⁻¹, respectively. From these data we hypothesized that differential activity in these foliar applications may be due to the relationship between foliar spray retention and in-water activity of the herbicides tested. Consequently, another study was conducted in 2020 and 2021 to evaluate the in-water activity of these herbicides on waterhyacinth. Waterhyacinth was treated by in-water injection across seven concentrations of glyphosate, 2,4-D, and diquat. As suspected, plants treated with 2,4-D or glyphosate did not exhibit herbicide symptoms at concentrations possible in operational applications. However, diquat translocated from the water column to leaf tips providing plant control and biomass reduction even at labeled concentrations. Therefore, these data suggest that 2,4-D and glyphosate largely rely on foliar uptake for waterhyacinth activity which is maximized under low carrier volumes that promote greater spray retention. Alternatively, diquat is very forgiving in terms of application technique and exhibits both foliar and in-water activity on waterhyacinth. Future work will evaluate these application parameters at operational scale as well as with other herbicides and plant species.

Trials to Evaluate “Natural” Herbicides for Aquatic Weed Management. (29) Lyn A. Gettys
University of Florida, Davie, FL

The 2019 FWC “pause” in herbicidal aquatic weed control has spurred interest in evaluating the efficacy and selectivity of alternative products for invasive species management in aquatic systems. We investigated the activity of a range of concentrations of acetic acid, d-limonene and citric acid after foliar applications to selected invasive floating and native emergent plants. Plants were co-cultured in 68L

mesocosms until floating plant coverage was > 80%, then treated once with a single product or combination (plus surfactant). Four replicates were prepared for each treatment and all plants were maintained for 8 weeks after treatment. Plants were then evaluated for visual quality, destructively harvested and placed in a forced-air drying oven for 2 weeks to determine reduction in biomass compared to untreated control (UTC) plants. In most cases, native emergent plants were not seriously damaged by treatments. Floating invasive species were adequately controlled (>80% reduction in biomass) by some treatments. However, these treatments are not yet labeled for aquatic use and deployment of these treatments at scale would result in at least a 22-fold increase in material costs alone. These data reveal that alternative products may be useful for aquatic weed management but more research – including field trials – is necessary to confirm these results.

Management of Old World Climbing Fern (*Lygodium microphyllum*) Under Varied Flooding Regimes. (30) **Candice M. Prince**¹, Stephen F. Enloe¹, James Leary¹, Jonathan Glueckert²

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Old World climbing fern (*Lygodium microphyllum*) is one of the most widespread and problematic invaders in South Florida. Old World climbing fern (OWCF) invades habitats that are prone to fluctuating water levels, such as the tree island communities of the Everglades. There is a need to better understand the effects of flooding on herbicide efficacy. To this end, we established a mesocosm study to evaluate the effects of pre- and post-treatment flooding on OWCF. Plants were established in mesocosms and raised 15 cm out the water. Pots were lowered 10 cm below the water line at specific intervals (0, 2, 4, or 6 weeks) prior to foliar applications of glyphosate at 3.75 lb a.e. acre⁻¹. Following treatment, plants were raised completely out of the water at specific intervals (0, 2, 4, or 6 weeks after treatment). Plants were evaluated for herbicide injury and aboveground biomass 6 weeks after treatment (WAT), and above- and below-ground biomass 12 WAT. This experiment will provide insight into the effects of fluctuating water levels on OWCF management.

Evaluating Subsurface Field Applications of ProcellaCOR® SC (A.I. Florpyrauxifen-benzyl) for Suppressing Hydrilla. (31) **James Leary**¹, Kelli Gladding¹, Jacob Thayer¹, Jonathan Glueckert¹, Benjamin P. Sperry²

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²US Army Corps of Engineers, Gainesville, FL

The goal of this proposed research is to build institutional knowledge on the operational use patterns of the new herbicide florpyrauxifen-benzyl (FPB) for controlling hydrilla under a variety of biophysical and environmental conditions that will support future lake management decisions by regional biologists. The objectives to meet this goal are to evaluate the efficacy of FPB on target hydrilla and the collateral symptoms of non-target species over space and time. Here, we will report on three lake sites ranging with one lake less than 40 ha and the other two each over 800 ha. These in-water treatments encompass 10-100% of the total water body and correspond to cove, littoral and whole-lake treatments, respectively. Two of the treatments on Lake's Parker and Thomas (Polk County) were administered in early January 2021 and we'll report on performance metrics at ~200 DAT. Lake Sampson (Bradford County) was received a large (370 ha) littoral treatment in late March and we'll report on similar metrics at ~100 DAT. The study team is utilizing institutional survey methods and data standards used by the Florida Fish and

Wildlife Conservation Commission augmented with high spatial resolution and temporal frequency. We'll be further highlighting the capabilities of satellite and airborne surveillance products enhancing the change detection profiles over space and time.

ORAL (Virtual)

Development of Selective Control Options for Chemical Management of Cuban Bulrush. (32)

Jackson Jablonski¹, Candice M. Prince¹, Stephen F. Enloe¹, Greg MacDonald¹, Benjamin P. Sperry²

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Cuban Bulrush (*Cyperus blepharoleptos*) is an aquatic invasive sedge in the southeastern United States that has become increasingly problematic over the last decade, displacing native plant communities and impeding navigation. However, there are limited descriptions of Cuban bulrush basic reproductive biology in the current literature. Here we conducted a series of seed experiments to evaluate viability, germinability, and the extent of dormancy of Cuban bulrush seed. Seed were collected from public waterbodies in Florida (Orange Lake and Lake Tohopekaliga) when the seed heads were brown and crumbling apart, and assumed to be at a mature stage for dehiscence. Viability assays were conducted using tetrazolium chloride (TZ) embryo staining; seeds were soaked in either 0.1% or 1% TZ for 8 to 17 hours in the dark at 21 to 37 degrees Celsius. Results indicated 39-45% viability; however, preliminary germination assays showed low (1-4%) germination. Therefore, a series of germination assays were conducted to evaluate the influence of temperature regimes, chemical scarification (potassium nitrate), gibberellic acid, dry after-ripening (20-30% relative humidity exposure), and cold (5°C) and warm (30°C) stratification on germination. Petri dishes containing 25 seeds each were placed in growth chambers under a 12-hr photoperiod with alternating day/night temperatures (22/11, 27/15, 29/19, 33/24). Seeds were assessed for germination every 3 days under 5X magnification for 30 days. The comprehensive understanding of Cuban bulrush seed biology gained from this research will inform more effective management practices.

Phenology and Starch Allocation Patterns of Cuban Bulrush (*Cyperus blepharoleptos*) Harvested from Field Locations. (33) Madeline M. Kjellesvig¹, Ryan M. Wersal¹, Gray Turnage²

¹Minnesota State University, Mankato, Mankato, MN

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Cuban bulrush is an epiphytic aquatic plant invading the southeastern United States. Cuban bulrush is capable of rapidly outcompeting other plant species such as water hyacinth and forms large monotypic floating islands. The purpose of this research is to understand the life history patterns of Cuban bulrush in order to exploit weak points in the plant's life cycle. This research is focused on the quantification of seasonal biomass and starch allocation patterns which both play a fundamental role in determining the life history of aquatic plants. Biomass and carbohydrate storage often vary seasonally for many plants where storage regularly peaks in summer or fall and depletes shortly after plant growth in the spring. Cuban bulrush emergent and submergent tissues show increased levels of starch and biomass in the

spring as growth is initiating. In the summer, there is an increase in average percent starch and biomass with some allocation to inflorescences. Cuban bulrush exhibits peak biomass in the fall from September to November. In October of 2019, maximum biomass was approximately 130 g DW m⁻². Starch allocation was maximized to emergent tissues in September of 2019 and submergent in October 2019 where average percent starch was 1.5 percent and 1.9 percent respectively. Data for winter months is showing typical senescence of tissues which is characteristic of annuals in the winter.

Evaluating the Response of Invasive Flowering Rush (*Butomus umbellatus*) Cytotypes to Chemical Control Measures. (34) **Jacob A. Hockensmith**¹, Gray Turnage², Cory Shoemaker³

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Establishment and spread of invasive species has affected ecosystems across the globe. These intruders compete with native species for resources, which often leads to reduced biodiversity as well as other environmental issues. Flowering Rush (*Butomus umbellatus*) is one such species that has invaded the northern United States and Canada. Flowering Rush is a perennial, aquatic species that can be found growing along the shoreline of lakes and other waterbodies. In North America, two distinct cytotype populations occur: diploid and triploid. These cytotypes differ in key anatomical and physiological properties. Despite these differences, current best management practices of chemical control are based solely off research conducted on triploid populations, which account for only 29% of flowering rush populations in North America. In this study, we assessed the effect of two commonly used chemical control measures for aquatic plants, Diquat and Endothall, on diploid and triploid cytotypes. After establishment and subsequent herbicide application, plants were followed to eight weeks post treatment. At this time the plants were harvested to assess the efficacy of the treatments on above- and belowground biomass accumulation, in addition to belowground asexual rhizomatous bud production. We observed that when treated with herbicides, bud production in diploid plants increased, while bud production in triploid plants was unaffected. Additionally, in diploid Flowering Rush, higher concentrations of Diquat and Endothall increased bud production compared to control and low concentration treatments. Both Diquat and Endothall reduced the overall above- and belowground biomass. Our results suggest that diploid and triploid populations display different reactions to chemical controls and that further research is needed to elucidate these differences.

Littoral Physical, Chemical, and Biological Characteristics Determining Submersed Aquatic Vegetation Distribution in a Freshwater Reservoir. (35) **Kara J. Foley**, Ramon Leon, Robert J.

Richardson

North Carolina State University, Raleigh, NC

Hydrilla (*Hydrilla verticillata* (L.f) Royle) is classified as a Federal noxious aquatic macrophyte in the United States. Philpott Reservoir (VA) supports a dominating population of dioecious hydrilla despite providing unideal conditions for submersed plant growth due to standard reservoir operations which include a high incidence of shoreline disturbance, minimal littoral area, and physically dense sediment composition. Three years of point-intercept surveys for submersed aquatic vegetation (SAV) presence, water quality data, and physical basin characteristics were evaluated using multivariate analyses to determine the factors that may be the most influential to SAV composition and distribution and hydrilla

dominance in the reservoir. Analyses utilized ordination, classification, and regression techniques through the application of principal components analyses (PCA), linear discriminant analysis (LDA), and multiple logistic regression (MLR). MLR produced three significant predictors of hydrilla: *Egeria* presence ($p = 0.0321$), secchi depth ($p < 0.0001$), and sediment composition ($p = 0.0092$). PCA revealed that these predictors are closely related to other environmental factors including the concentration of total nitrogen in the water column, water pH, and water depth. In an attempt to group species by the collected environmental variables in a constrained space, an LDA model correctly classified 64.4% of points by species presence. These multivariate models suggest that, despite the fairly generalist needs of hydrilla in aquatic ecosystems, the distribution of hydrilla in Philpott Reservoir may be largely driven by the underlying physical properties that influence higher chemical and ecological processes.

Aquatic Macrophyte Communities in Five Sibley County (Minnesota) Lakes and the Factors That Affect Their Distribution. (36) **Samuel A. Schmid**, Ryan M. Wersal
Minnesota State University, Mankato, Mankato, MN

The purposes of this study are to 1) quantify the shifts in the macrophyte community structure of five lakes in Sibley County, and 2) to assess the relationships between the macrophyte communities and abiotic factors in these five lakes. In both the early and late growing season of 2019, point-intercept surveys were conducted on High Island Lake, Titlow Lake, Schilling Lake, Silver Lake, and Clear Lake. At each point, water depth was recorded, and all macrophytes sampled were identified and recorded as “present.” The macrophyte community shifts in individual lakes during the growing season were quantified by comparing the species presence/absence and mean species richness in the early season to the late season. Additionally, in the early season, a sediment core was retrieved at each point for analysis. All sediment cores were analyzed for particle size and sediment organic matter using the hydrometer method and loss on ignition respectively. In order to assess the relationships between the macrophyte community and abiotic factors at individual lakes, generalized linear regressions were ran with the mean species richness as the dependent variable and water depth, distance from shore, percent sand, percent silt, percent clay, and percent sediment organic matter as explanatory variables. The analyses of the macrophyte community shifts suggest that macrophyte phenology is a primary factor that affects the shifts in community structure over the growing season. The generalized linear regressions identify water depth, distance from shore, and percent silt as significant predictors of mean species richness in multiple models. Water depth and distance from shore are both negatively related to mean species richness in multiple models. Whether silt is positively or negatively related to mean species richness is dependent on the species composition of that lake.

The Ecology of Submersed Aquatic Vegetation Communities Under Management in Select Florida Lakes. (37) **Jacob Thayer**, James Leary, Candice M. Prince, Kelli Gladding
University of Florida, Gainesville, FL

Submersed aquatic vegetation (SAV) is a major ecological component of Florida's shallow lake systems. Hydrilla (*Hydrilla verticillata* [L.F.] Royle) is a non-native SAV dominating many of these lakes and is often observed to be growing in large monotypic cultures exclusive to other native SAV community members. This invasive species is the number one priority for aquatic plant management in the state of Florida with desired outcomes to conserve native SAV diversity. We are studying the effects on SAV community ecology from selective hydrilla management activities. This investigation is being conducted

in two mesotrophic systems, Lake Sampson (804 hectares) in Bradford County and Lake Mann (107 hectares) in Orange County. Surveys have been conducted before and after selective herbicide treatments that were administered in early spring of 2021. Data on species and abundance were recorded with point intercept, hydroacoustic, and airborne imagery surveys on monthly intervals offering community structure data with high spatial and temporal resolution. Here, we present on some of the basic attributes in community ecology consisting of native and nonnative patch networks along with local and lake-level diversity indices to describe patterns of environmental filtering and competitive exclusion. Furthermore, replacement series competition experiments were conducted in mesocosms between native and invasive species as a complement to the field trials. Selective hydrilla management should enhance local composition of native SAV communities.

Hybridization and Invasiveness in Eurasian Watermilfoil (*Myriophyllum spicatum*): is Prioritizing Hybrids in Management Justified? (38) **Hannah K. Hoff**, Ryan A. Thum
Montana State University, Bozeman, MT

Hybridization can play an important role in the evolution of invasiveness. Eurasian watermilfoil (*Myriophyllum spicatum* L.; EWM) is a widespread aquatic invasive plant species that hybridizes with native northern watermilfoil (*Myriophyllum sibiricum* Kom.). Previous studies have found mixed evidence for whether hybrid watermilfoil (*Myriophyllum spicatum* × *sibiricum* Kom.; hereafter, hybrids) and pure EWM differ in vegetative growth rate and herbicide response. While several studies have emphasized variation among hybrid genotypes in their vegetative growth rate and herbicide response, genetic variation within pure EWM has not been considered. Therefore, it is unclear how important genetic variation within EWM, versus between pure EWM and hybrids, is in influencing invasive traits and management outcomes. If hybrid genotypes are always more invasive than pure EWM genotypes, simply distinguishing taxa may be sufficient for identifying lake management priorities; however, if significant phenotypic overlap is observed between taxa, distinguishing individual genotypes may be more important in tailoring management strategies. We performed replicated trials of a vegetative growth and 2,4-D assay to measure clonal variation in growth rate and herbicide response in EWM and hybrids. Our results suggest that hybrids exhibit higher average vegetative growth than EWM, whether or not they are treated with 2,4-D. We did not observe interactions between taxon and treatment or between genotype and treatment. Despite differences between taxa in average growth, there was substantial phenotypic overlap between EWM and hybrids. For example, we found that the fastest-growing genotype of pure EWM did not differ significantly in average growth from the fastest-growing hybrid genotype in control or in treatment; thus, pure EWM genotypes may be comparatively invasive to some hybrid genotypes. The potential for overlap between invasive watermilfoil taxa suggests that distinguishing and characterizing genotypes may be more informative for managing invasive watermilfoil than simply distinguishing between EWM and hybrids.

Unmanned Aerial Application Systems for Aquatic Plant Control: Case Studies in North Carolina. (39) **Andrew W. Howell**¹, Tyler Harris², Robert J. Richardson²
¹North Carolina State University, Pittsboro, NC
²North Carolina State University, Raleigh, NC

The recent integration of small unmanned aerial systems (sUAS) in aquatic plant management has generated several avenues for researchers and managers to explore. Commonly, sUAS are deployed as

optical sensing evaluation tools for invasive plant detection, documenting species composition and cover, or capturing visual control assessments during active management. However, some sUAS also provide opportunity to remotely deliver herbicide applications. Within a given aquatic system, there are often inaccessible or difficult to treat regions due to shallow water, lack of boat launch facilities, or potential obstructions and hazards in the treatment zone. Many managers anticipate the potential benefits of deploying herbicide delivering sUAS, specifically as an opportunity to treat areas where using watercraft is not feasible, or convenient. Likewise, there is an added benefit of reduced human exposure during application. While interest in sUAS sprayers remains high, these systems are not commonplace for management yet, often due to regulatory and payload constraints. To provide validation of operational use, we evaluated an off-the-shelf sUAS sprayer in different weed scenarios to control submersed and floating vegetation (*Myriophyllum heterophyllum* and *Nymphoides peltata*, respectively). Some items tested included spray nozzle selection, effort and ease of operation, and visual control levels of target plant species. Manual and semi-autonomous capabilities were also documented. Discussion will provide summary of system constraints and the effectiveness of sUAS sprayers as a unique management tool. Further evaluations are planned to determine application tactics for floating plant control.

Small-scale Efficacy Screenings of Florpyrauxifen-benzyl in Combination with Either Chelated Copper or Endothall for the Control Monoecious Hydrilla. (40) Erika J. Haug, Jens P. Beets, Robert J. Richardson
North Carolina State University, Raleigh, NC

Invasive aquatic plant species, such as monoecious *Hydrilla verticillata*, can have far reaching negative impacts to ecosystems including interference in flow patterns, disruption of predator/prey dynamics and changes to water quality. Previous research has shown that combining modes of action can improve the efficacy of herbicide treatments, while reducing use rates and mitigating the potential for tolerance development. Trials were conducted at NC State University to compare efficacy of florpyrauxifen-benzyl (30ppb), chelated copper (0.5ppm) and endothall (1.5ppm) alone and in combination for the control of monoecious *Hydrilla verticillata*. All herbicides were tested at both 24-hour and 72-hour exposures. Weekly visual ratings were conducted, and a complete destructive harvest was performed at the conclusion of the trial six weeks after treatment. Preliminary results suggest no significant difference in biomass between untreated controls and 24-hour exposures to each of the products alone at the rates tested. In general, a significant increase in control was observed when products were combined as compared to each herbicide alone. While 24-hour exposures to florpyrauxifen-benzyl or chelated copper alone did not result in a statistically significant reduction in biomass, a 24-hour exposure to the combination of these herbicides resulted in a significant 87% reduction in biomass as compared to the control. Results and applications for management will be discussed.

Monitoring Monoecious Hydrilla in Flowing Water Systems of North Carolina. (41) Robert J. Richardson¹, Jens P. Beets¹, Erika J. Haug¹, Benjamin P. Sperry², Tyler Harris¹
¹North Carolina State University, Raleigh, NC
²US Army Corps of Engineers, Gainesville, FL

Hydrilla (*Hydrilla verticillata*) is a pervasive noxious weed that has invaded many waterbodies in the United States. *Hydrilla* infestations have the potential to negatively impact aquatic ecosystems and local economies, impeding water flow and displacing native vegetation. Historically, hydrilla has been

particularly problematic in lakes in reservoirs. However, in recent years hydrilla has become an increasing nuisance in flowing systems such as the Erie Canal, Cape Fear River, Lake Panasoffkee Outlet River, as well as irrigations and drainage canals. This monitoring effort seeks to improve understanding of hydrilla present in flowing systems, with a comparison to a non-flowing system. Three sites were selected on both the Deep and Neuse Rivers of North Carolina, with three non-flowing reference sites on Lake Raleigh, NC. An analysis of current findings concerning differences in life stage, sprouting of turions and tubers, as well as sprout length will be provided. Quarterly biomass harvests and an annual tuber density survey will also be performed. This monitoring is also part of a collaboration with the University of Florida, with mirrored sampling and monitoring on dioecious hydrilla in Florida.

***Amynothrips andersoni*, Evaluating a Potential Tool for Managing Alligatorweed in Temperate Climates.** (42) **Ian A. Knight**, Nathan E. Harms
US Army Corps of Engineers, Vicksburg, MS

Poor cold tolerance of the alligatorweed flea beetle, *Agasicles hygrophila*, and the northern expansion of alligatorweed, *Alternanthera philoxeroides*, has created a climate mismatch between the two, resulting in poor biological control in temperate zones. This may be compounded by the increasing prevalence of Ap6, an alligatorweed haplotype less suitable to flea beetles, with latitude. Alligatorweed thrips, *Amynothrips andersoni*, introduced to the southeaster US alongside the beetles have since received little attention. Studies from their native range, and the discovery of populations at temperate sites in the US, suggest these previously overlooked agents may be employed to manage alligatorweed in the US. To better understand the value of *A. andersoni* as a biological control tool, experiments were conducted to investigate impact and relative cold tolerance of the agent. To measure impact, shoots of common haplotypes Ap1 and Ap6 were infested with densities of 0, 2, or 4 adult thrips and populations were allowed to increase for one generation before assessing thrips and alligatorweed production. Cold tolerance of the thrips was compared to the flea beetles using two estimates of cold tolerance: critical thermal minimum and chill coma recovery time. In one month, thrips damage reduced emergent alligatorweed biomass by 6.2 and 18.5% in the low and high density treatments, respectively. Conversely, alligatorweed biomass below the surface of the water increased by 33.5 and 40.7%. No differences in impact or thrips reproduction was observed between haplotypes. The thrips were more cold tolerant as measured by CT_{min} which was 2°C lower than that observed for the flea beetles. The greater cold tolerance of the thrips explains their persistence in temperate regions of the United States. Along with anecdotal accounts of reductions in alligatorweed growth there, suggests thrips may be an important tool for managing alligatorweed at higher latitudes where flea beetles cannot persist.

POSTER

Evaluating the Long-term Effects of Aquatic Invasive Plant Management on Florida Plant Communities. (43) **Amy E. Kendig**, Mark V. Hoyer, James Leary, S. Luke Flory, Candice M. Prince
University of Florida, Gainesville, FL

Florida lakes are diverse ecosystems, enjoyed by residents and tourists alike. Many, however, are inhabited by non-native, invasive macrophytes that disrupt native species habitat, flood conveyance, navigation, and water quality. Three of the highest priority invasive plant species include submersed hydrilla (*Hydrilla verticillata*), floating water hyacinth (*Eichhornia crassipes*), and floating water lettuce (*Pistia stratiotes*). Public agencies actively manage tens of thousands of hectares of freshwater systems to bring these invasive plant species under maintenance control. However, stakeholder perceptions associating aquatic plant management with negative environmental impacts in Florida lakes led to a pause on herbicide spraying in 2019. While short-term studies on select Florida lakes have provided important insights on impacts of herbicides and invasive macrophytes, long-term data collected across a large spatial scale can help disentangle multiple drivers, including herbicide use, of the current state of managed lakes in Florida. As a first step, we seek to understand the direct and indirect impacts of herbicide use over space and time on invasive species abundance and native plant richness. Here, we will describe the framework of a state-space model designed to incorporate large, disjointed datasets collected by multiple agencies spanning 37 years and over 350 lakes. We will provide background information on the datasets, the analytical methodology, and preliminary results of the model. We hypothesize that herbicides have short-term direct negative effects on both invasive species abundance and native species richness, but long-term indirect positive effects on native species richness. The results of this analysis will improve our understanding of the long-term outcomes of aquatic invasive plant management in lake conservation.

Regenerative Potential of Hydrilla Fragments Following Desiccation. (44) **Taylor L. Darnell**¹, Candice M. Prince¹, Benjamin P. Sperry²

¹University of Florida, Gainesville, FL

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Hydrilla verticillata (hydrilla) is an aquatic invasive plant that forms dense mats in waterbodies. These mats break apart when watercraft pass through them, and lodge on different parts of the vessel and boat trailer. Stem fragments can subsequently be carried to other waterbodies where they can establish new populations; however, little is known about their ability to regenerate following periods of desiccation (i.e., on a boat trailer). Our objective was to evaluate the desiccation tolerance of individual and clumped fragments. Plant material was desiccated for predetermined intervals, rehydrated for 48 hours, and post-rehydration, stems and tips that were unbleached, turgid, and green were planted out and carried for two weeks and harvested. The regenerative capacity of fragments and clumps was a significant function of both desiccation time and fragment and clump size. Destructive dry weight data were regressed over desiccation time using three and four parameter log-logistic model which shows an ED₅₀ (effective time needed to inhibit 50% of the population from surviving values for individual fragments to be 0.90, 0.94,

and 0.68 hours for fragment sizes of 7, 15, and 30 cm, respectively, with respective ED₉₀ values of 0.99, 1.02, and 1.03 hours. For clumps, ED₅₀ values were 1.24, 1.81, 1.95, 3.0 hours for 1, 3, 6, and 12 fragment clumps, respectively, while the ED₉₀ values were 2.13, 2.27, 3.6, and 6.15 hours. These data suggest that longer, denser clumps have an increased ability to establish new colonies elsewhere.

Notes:_____

[illegible]



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