41st WAPMS Conference

WESTERN AQUATIC PLANT MANAGEMENT SOCIETY

76th WSWS Conference

WESTERN SOCIETY OF WEED SCIENCE

February 27th - March 2nd, 2023

The Grove Hotel ~ Boise, Idaho

WAPMS.ORG *WSWEEDSCIENCE.ORG*

Past WAPMS Meetings Sites and President

2022	Tucson, AZ	Cory Greer
2021	Virtual (joint meeting w/WSWS)	Tom Warmuth
2020	-	-
2019	Mission Viejo, CA (joint meeting w/APMS)	Andrea Sealock
2018	Reno, NV	Amy Ferriter
2017	Coeur d'Alene, ID (joint meeting w/ WSWS)	Scott Nissen
2016	San Diego, CA	Joseph Vassios
2015	Portland, OR	Patrick Akers
2014	Reno, NV	Cody Gray
2013	Coeur d'Alene, ID	Mark Sytsma
2012	San Diego, CA	Toni Pennington
2011	Westminster, CO	Thomas Moorhouse
2010	Seattle, WA	Robert Leavitt
2009	Honolulu, HI	Tom McNabb
2008	Tahoe City, CA	Scott Shuler
2007	Coeur d'Alene, ID	Ross O'Connell/ Lars Anderson
2006	San Diego, CA (25th Meeting)	Jenifer Parsons
2005	Denver, CO	George Forni
2004	Bellevue, WA	Terry McNabb
2003	Sacramento, CA	Shaun Hyde
2002	Coeur d'Alene, ID	Mike Mizumoto
2001	Las Vegas, NV	Ron Crocket
2000	Bozeman, MT	Valerie Van-Way
1999	Reno, NV	Stuart Perry
1998	San Diego, CA	Kathy Hamel
1997	Seattle, WA	Mark Sytsma
1996	Portland, OR	Vanelle Peterson
1995	Sacramento, CA	Fred Ryan
1994	Coeur d'Alene, ID	Paul Beatty
1993	Tucson, AZ	Lars Anderson
1992	Salt Lake City, UT	David Spencer
1991	Seattle, WA	Richard Thiery
1990	Sparks, NV	Tom McNabb
1989	Honolulu, HI	Barbra H. Mullin
1988	Fresno, CA	Fred Nibling
1987	Boise, ID	Winn Winkyaw
1986	San Diego, CA	Randall Stocker
1985	Phoenix, AZ	Nate Dechoretz
1984	Spokane, WA	Les Sonder
1983	Las Vegas, NV	Terry McNabb
1982	Denver, CO	First Business Meeting Terry McNabb (President); Paul Beaty (VP)
1981	Formation Interest meeting, San Diego, CA - Floyd Colbert and Lars Anderson (Co-chairs)	

Board of Directors

The objectives of the Society shall be to:

1. Establish a forum for the exchange of information on aquatic vegetation management techniques, strategies, and research through periodic meetings and other appropriate means.
2. Cooperate with local, state, regional, and national agencies, both public and private, in the identification of and solution to aquatic vegetation problems.
3. Promote uniformity and coordination of activities among agencies concerned with the regulatory aspects of aquatic plant management.
4. Encourage scientific research and assist in promoting the control and management of aquatic plants through scientifically sound procedure.
5. Recognize and promote scientific advancement of the members and facilitate the education of aquatic plant scientists through scholarship and other assistance programs.
6. Extend and develop public interest in, and understanding of, aquatic plant management problems and solutions.
7. Cooperate with local chapters and other organizations with similar and related interests.

The Western Aquatic Plant Management Society geographic region includes the states of:
Alaska, Arizona, California, Colorado, Hawaii, Idaho, Oregon, Nevada, New Mexico, Montana, Utah, Washington, and Wyoming

WESTERN AQUATIC PLANT MANAGEMENT SOCIETY

joint meeting with

WESTERN SOCIETY OF WEED SCIENCE

February 27th - March 2nd, 2023

The Grove Hotel ~ Boise, Idaho

PROGRAM

Monday, February 27

12:00 – 9:00	**Conference Registration & Exhibition/Posters Set Up**
6:00 – 9:00	**Welcome Reception** Boise Centre West – Room 100A

Tuesday, February 28

WAPMS Sessions will be held in the Boise Centre West, Room 120A

9:00 – 12:00	**Welcome to the WAPMS & WSWS Conference, Registration and CEU Sign-in, Updates, and Keynote Speakers**
9:00 – 9:05	**Intro and Announcements** Curtis Rainbolt; BASF, Meridian, ID
9:05 – 9:20	**Western Society of Weed Science Presidential Address** Joel Felix; Oregon State University, Ontario, OR
9:20 – 9:35	**Western Aquatic Plant Management Society Presidential Address** Douglas Kleweno; Cygnet Enterprises, Inc., Camas, WA
9:35 – 9:50	**Women of Aquatics Update** Amy Kay; SOLitude Lake Management, Oakwoods Hills, FL
9:50 – 10:00	**Aquatic Ecosystem Restoration Foundation Update** Carlton Layne; Executive Director, AERF, Marietta, GA
10:00 – 10:10	**Aquatic Plant Management Society Update**
10:10 – 10:30	**DC Update** Lee Van Wychen; Executive Director of Science Policy, WSSA, Alexandria, VA
Session A 10:30 – 11:45	**Keynote Speakers**

10:30 – 11:15 **Challenges and Adaptive Management Opportunities in Breaking the Annual-grass Fire Cycle: Insights from the Boise and SW Idaho Area**
Matt Germino, Supervisory Research Ecologist, FIREss team: Fire, Invasives, and Restoration Ecology of Sagebrush Steppe

11:15 – 11:45 **Facing Water Management Challenges Throughout the West - a Federal Perspective**
Roland Springer, Deputy Regional Director, Columbia-Pacific Northwest Region, Bureau of Reclamation

11:45 – 1:15 **Lunch** (On your own)

Session B

1:15 – 3:15 **Water in the West: Implications for Weed Management**
Moderators: Jane Mangold and Mirella Ortiz

1:15 – 1:45 **Western US Climate Change Trends & Spring Seasonal Outlook**
Sophia Adams, National Weather Service Meteorologist, WFO Boise, ID

Abstract
Anthropogenic climate change will have a drastic impact on water resources, weather, and climate in the Western United States. This presentation will cover the current trends and basic information about climate change. Different climate models will be presented along with the corresponding predicted outcomes throughout the Western United States. From these climate model predictions, various potential weather and agricultural impacts for the Western United States will be explored. Additionally, the Climate Prediction Center's seasonal outlook for spring and summer 2023 and the current SWE (snow water equivalent) measurements from SNOTELs (Snow Telemetry Network) for the Western United States will be presented.

1:45 – 2:15 **Evolving Water Resource Management in the Southwest**
Charles Ester III, Salt River Project

Abstract
The Salt River Valley in south central Arizona was once an agricultural paradise. The building of Roosevelt Dam in the early 1900s as the cornerstone of the US Bureau of Reclamation's Salt River Project (SRP) secured an adequate and reliable supply of water to the area. The dependable water supply and yearlong growing season allowed agriculture to flourish. Vibrant agriculture gave way to increasingly rapid urbanization following World War II. Today, the Salt River Valley is home to the nation's 5th largest city, Phoenix. The change from an agricultural community to a vast metropolitan area has required SRP to be responsive to the changing needs of our constituents. Adaptations once driven by local issues are now being influenced by regional and even world scale concerns like the overallocation of Colorado River to climate change impacts. SRP has and will continue to adapt and evolve its water resource management practices to ensure the ability to provide the adequate, reliable, and sustainable water supply our shareholders have come to depend.

2:15 – 2:45 **Follow the Water—Invasive Plants and Global Change in a Dry Grassland – Virtual Presentation**
Dana Blumenthal, Research Ecologist, USDA-ARS Rangeland Resources & Systems Research Unit, Fort Collins, CO

Abstract
As global changes alter plant communities, a key question is how invasive plants will respond. Since 2003, we have been testing how global changes influence invasion in mixedgrass prairie, focusing on changes that influence water, the key limiting resource. We found that while increased snow, summer precipitation, and nitrogen deposition all facilitated invasion, increased snowfall had the strongest effects, allowing invasion

by three species, diffuse knapweed (*Centaurea diffusa*), baby's-breath (*Gypsophila paniculata*), and Dalmatian toadflax (*Linaria dalmatica*), that were rarely observed under ambient conditions. In subsequent experiments where we manipulated atmospheric CO2 and warming, both Dalmatian toadflax and diffuse knapweed responded strongly to elevated CO2, increasing above ground biomass by more than an order of magnitude, while warming had little effect. While the dominant perennial grass, western wheatgrass (*Pascopyrum smithii*) decreased stomatal conductance under elevated CO2, Dalmatian toadflax maintained high stomatal conductance and increased photosynthesis, suggesting that its strong CO2 response may be facilitated by less conservative water use. Finally, cheatgrass (Bromus tectorum) responded positively to warming (but not elevated CO2), likely due to an expansion of its distinct phenological niche. Together, these results suggest that global change will pose additional challenges for revegetation in semi-arid regions, and that changes that alter water availability will have the strongest influence on invasion.

2:45 – 3:15 **Traits that Confer Weediness also Facilitate Adaptation to Climate Change**
Ian Burke, Washington State University

Abstract

Changing climate will affect weed biology, with consequences for management across the western United States. Weed response to climate change have focused on two main areas: competition between plants of different photosynthetic functional groups under conditions of increased temperature and CO2 concentrations, or range shifts of weedy plant species on a regional scale. However, functional traits regulated by external environmental cues will facilitate response to climate variability and likely contribute to success for weed populations. Indeed, those traits are currently facilitating success by weeds across climate clines currently present across the western United States. Furthermore, the same traits in crop species are tightly controlled or eliminated in certain cases, likely creating niches for weeds to fill as weed populations adapt to climate, but crops lag in adaptation due to the inherent lag typical of plant breeding programs. Important traits regulating seed dormancy, germination, emergence, above ground growth, and floral initiation are under continuous selection by climate as well as management. Consideration of these traits will not only facilitate understanding how weeds will respond to climate, but also facilitate their management.

3:15 – 3:30 **Break**

Session C

3:30 – 5:00 **Continuation Water in the West: Implications for Weed Management**
Moderators: Jane Mangold and Mirella Ortiz

3:30 – 4:00 **Predicting Plant Invasions Under Climate Change in Aquatic and Riparian Systems in the Pacific Northwest**
David R. Clements[1], Emma Nikkel[2], and Jennifer Williams[2]; [1]Trinity Western University, Langley, BC, Canada; [2]University of British Columbia, Vancouver, BC, Canada

Abstract

Climate change predictions for the Pacific Northwest region of North America include both warmer and more unpredictable weather, such as extreme events like floods and droughts. There are numerous invasion pathways for aquatic or riparian non-native plants in the Pacific Northwest. Aquatic environments are expected to warm more gradually than terrestrial environments, but if freezing occurs less frequently bodies of water could be vulnerable to new plant invasions. Increased frequency of extreme climate events such as flooding favor many invasive plant species adapted to dispersing or reproducing under such conditions. We will discuss factors that predict such plant invasions, within a framework incorporating climate dynamics, ecosystem resistance, and invader fitness. Shifts under climate warming will be reviewed for one group of plants, and a second group will be examined in terms of extreme events. The first group will include water hyacinth (Pontederia crassipes), water lettuce (*Pistia stratiotes*), floating heart (*Nymphoides peltatum*), parrot feather (*Myriophyllum aquaticum*), and flowering rush (*Butomus umbellatus*). The second group will include Phragmites (*Phragmites australis*), giant reed (*Arundo donax*), Himalayan balsam (*Impatiens glandulifera*), Tamarix (*Tamarix ramosissima*), Buddleia (*Buddleia davidii*), and knotweeds (*Reynoutria*

spp.). These case studies point to the need for more research on how changing conditions in aquatic systems predict the vulnerability of sensitive habitats to invasion by these and other species of concern. Better monitoring of aquatic sites is needed as aquatic and riparian species have frequently gone undetected for years or have rapidly increased in response to changing conditions resulting in more flooding. As well as vigilance, ultimately the goal should be to increase ecosystem resistance in the Pacific Northwest to help prevent large scale invasions that have been recorded for many of these species, either in this region or in other regions of North America and throughout the world.

4:00 – 4:30 **Runaway Lakeshores and Widespread Plant Invasions: Insights on Revegetating Wetlands in the Arid West**

Jes Braun and Karin Kettenring, Utah State University

Abstract

Revegetating lakeshores post-invader removal is a challenging task. Alongside the threat of reinvasion, there are unpredictable weather patterns, exceptional drought conditions, and increasing water demand. Nonetheless, to achieve ecosystem management goals, practical solutions for revegetation must be developed. Two key decision points are (1) where should vegetation be reintroduced as lakeshores rapidly recede over the growing season and (2) what seeding or planting strategies optimize native plant establishment in the face of reinvasion? We addressed these questions in a lakeshore revegetation experiment on Utah Lake, a highly valued aquatic ecosystem in the Intermountain West that is experiencing dramatic water loss from upstream diversions and invasions by the non-native grass Phragmites australis. Here we present the results from a multi-year revegetation experiment where we looked at the effects of seeding density, plug planting, and elevation on the establishment of native vegetation. We seeded a 19-species seed mix of functionally diverse native plants at low (the typical seeding rate) and high (five times the typical seeding rate) densities. The results suggest that higher seeding density decreases invasive cover, however some higher density seeded areas experienced reduced species richness. Elevation of plug planting was a strong indicator of establishment over the two years of monitoring. Seeded elevations closest to the lake had the least amount of invasive cover and can be a prime area to target for restoration, however too close to the lake can lead to seed loss. Species richness increased over time, with some seeded species taking two years to germinate. In addition to this experiment, we conducted an extensive review and synthesis of the lakeshore revegetation literature. In our Extension publication "Best practices for lakeshore revegetation in the eastern Great Basin", we share our findings and provide a step-by-step guide for successful revegetation. We discuss the importance of careful planning and species selection, as well as the need for monitoring projects for continuous learning. Our goal is to empower others to restore the vegetation of lakeshores in the eastern Great Basin and ensure that these vital resources remain healthy for future generations.

4:30 – 5:00 **Water & Weeds: Supporting Idaho's Thriving Agricultural Economies**

Paul Arrington, Executive Director & General Counsel, Idaho Water Users Association

Abstract

At its core, Idaho is an agricultural state. Agriculture counts for nearly one quarter of the total state GDP. Water is, perhaps, the most vital component of this industry. In fact, farming, ranching and food processing would not be possible without water. In Idaho, water is largely delivered to farms and ranches through a series of canals, laterals and ditches. It is common for water management organizations to be responsible for hundreds of miles of these facilities. Weed control is an essential component of the management of these facilities. Water organizations throughout Idaho implement rigorous weed management programs to ensure that water is safely and efficiently delivered through their systems. This presentation will discuss weed management from the perspective of a water manager.

5:00 – 6:30 **Students Reception**

Wednesday, March 1

WAPMS Sessions will be held in the Boise Centre West, Room 120A

Session D

7:00 – 10:15 **Registration, Posters, WAPMS/WSWS Conference, Registration and CEU Sign-in.**

7:15 – 8:45 **Poster Session**

8:45 – 9:15 **Artificial Intelligence Algorithm Development for Harmful Algal Bloom Prediction**

Kerry Caslow[1], Frederic Leroudier[2], and Andrew Luessenhop[1]; [1]In-Situ, Inc., Fort Collins, Colorado; [2]BiOceanOr, France

Abstract

Remote sensing and ground-truth sensor technology must continually evolve to provide the robust datasets needed for modeling and prediction of significant water-related events that could be harmful to health of many species. The In-Situ, Inc. and BiOceanOr partnership developed in early 2022 surrounds prediction of HABs in Lake Erie. Through the combination of remote sensing, ground-truth sensors as part of a smart watershed, and artificial intelligence, potential algae bloom growth and effects can be determined for more effective response and decision- making. Algorithms developed by BiOceanOr using In-Situ sensors and external satellite data are currently predicting algae blooms and dissolved oxygen fluctuations in other regions of the world. The Cleveland Water Alliance testbed program has provided a substantial opportunity to continue developing algae-centric algorithms, expanding scientific knowledge of bloom spread in the region through public data dissemination

9:15 – 9:35 **The Very Recent Hydrilla Invasion on Lake Apopoka, Florida: A Wickedly Big Problem with a Need for Immediate and Long-Term Solutions**

James Leary PhD*[1], Assistant Professor Agronomy Department, Center for Aquatic and Invasive Plants, University of Florida, J., N. Visscher [2], K. Gladding [1], and J. Glueckert [1]; [1] Center for Aquatic and Invasive Plants, Institute of Food and Agricultural Science, University of Florida, [2] Invasive Plant Management Section, Florida Fish and Wildlife Conservation Commission

Abstract

Lake Apopka is the 4th largest lake in Florida at 12,500 ha and serves as the head waters for the Ocklawaha River tributary. In the early 20th century, Apopka was a world-class bass fishing destination dominated by native submersed aquatic vegetation (SAV), especially southern naiad (*Najas guadalupensis*), eelgrass (Vallisneria americana) and Illinois pondweed (*Potamogeton illinoensis*). Decades of anthropogenic eutrophication switched Apopka, in the 1940s, from a SAV fishery habitat to an algal-dominant "green" lake. In the 1990s, nutrient reduction programs resulted in exponential declines in phosphorous and chlorophyll-a, over the next 30 years, concomitantly increasing water clarity and very suddenly promoting the expansion of surface hydrilla to >4000 ha in 2021. This forced an immediate, large-scale intervention in 2022, with in-water herbicide treatments covering 2500 ha using the active ingredients, endothall (406 ha), florpyrauxifen-benzyl (414 ha) and fluridone (1734 ha). Here, we will report on some of the early outcomes less than a year after treatment. In particular, the novel use of fluoridone as a sectional treatment will be highlighted. Overall, hydrilla was effectively suppressed in the treated areas, while continuing to expand in untreated areas. Nutrient reductions will continue to create an environment conducive for SAV to thrive. Importantly, restoration plantings of naiad, eelgrass and pondweed are starting to thrive near shore but pales to the rates of hydrilla expansion. The long-term goal is to promote the original native SAV communities, but the long-term strategy to get past the hydrilla gauntlet is still in the adaptive phase of development.

9:35 – 9:55 **What is the Desired Oxygen Level in the Water and at the Sediment- Water Interface in a Lake? A Literature Review and Possible New Paradigm Shift**

Patrick Goodwin, PhD, Naturalake Biosciences

Abstract

Oxygen is an important water quality parameter that governs many chemical, biological, and physical aspects of lakes. Managing desired oxygen levels has become a common lake restoration practice worldwide. Desired oxygen levels to address water quality issues in the literature and for lake projects have varied substantially from 1 to 20 mg/L dissolved oxygen (DO) in water or right above the sediment-water interface. Desired oxygen levels for lake projects are often set based on published peer-review papers or regulatory agency websites. However, there is a wide range of recommended oxygen levels reported, and many do not reflect recent advances in our understating of oxygen and its role in an aquatic ecosystem. For example, literature as recent as 2015 has stated that 2 mg/L DO is needed to prevent sediment release of reduced metals and nutrients to the overlying water. This is, however, an oversimplification that 1) has not held true in numerous oxygen management projects attempting to reduce metals and sediment nutrient release to the water and 2) does reflect recent advances in our understanding of sediment features and redox chemistry. In this presentation, a literature review will be presented discussing the desired oxygen levels to meet a specific water quality goal, current methods used to determine the efficacy of oxygen management, and methods to achieve it.

9:55 – 10:15 **The Effect of Repeated Clipping on Dioecious Hydrilla Subterranean Turions**

Taylor L. Darnell*[1], Benjamin P. Sperry[2], Candice M. Prince[3]; [1]University of Florida/Center for Aquatic Invasive Plants, Gainesville, FL, [2]US Army Corps of Engineers, Gainesville, FL, [3]University of Florida, Gainesville, FL

Abstract

Hydrilla (*Hydrilla verticillata*) is one of the most problematic aquatic weeds, and one of the most expensive to manage. Hydrilla produces subterranean turions (i.e., tubers) that facilitate regrowth of the population following herbicide application. However, little is known about tuber physiology, sprouting mechanisms, longevity of the tuber bank, or tuber response to adverse environmental conditions. Here, we evaluated the effect of repeated shoot biomass removal on dioecious hydrilla tubers. Shoot biomass was clipped five times over the study period (Dec. 2021 - May 2022), following one of four clipping schemes (900 tubers per experimental run): 1) no clipping (control), 2) removal of all sprouted biomass, 3) removal of the apical tip(s) and 3 or 4 whorls of leaves, and 4) removal of biomass above the third whorl of leaves. This experiment was replicated in space. We recorded the initial tuber weight, as well as length and weight of removed biomass for each clipping time (every 35 days for clipping #1-3, and every 45 days for clipping #4 and #5). For control tubers, we recorded shoot and tuber biomass. Data were regressed over initial tuber starting weights to evaluate the depletion of carbohydrate reserves. The number of clipping events significantly reduced tuber and shoot biomass. The removal of the apical meristem and several whorls of leaves had stimulated biomass production (1.03 g [shoot and tuber weight], compared to 0.83 g for non-clipped tubers), while removal of all sprouted biomass as well as biomass above the third whorl of leaves decreased biomass production over time. Results suggest that total removal of sprouted biomass may be more effective at exhausting a tuber's starch reserves than other biomass removal techniques. The removal of all biomass led to secondary node sprouting in several replicates, suggesting that secondary or tertiary node spouting is possible.

10:15 – 10:25 **Break**

Session E

10:25 – 11:30

10:25 – 10:30 **Intro for next 3 Speakers**
Dennis Zavaglo, Tahoe Regional Planning Agency (TRPA)

10:30 – 10:50 **Implementation of the Control Management Test (CMT) at the Tahoe Keys Lagoons, Part 1**
Lars Anderson, PhD, Waterweed Solutions, Pt. Reyes, CA. Tahoe Keys Property Owners Association; Sierra Ecosystem Resources

Abstract
The planning, design, and implementation of the CMT is the result of a 5-year sustained collaboration among Tahoe Keys homeowners (Tahoe Keys Property Owners Association), regulatory agencies (Lahontan Reginal Water Quality Control Board and Tahoe Regional Planning Agency), The League to Save Lake Tahoe and other stakeholders, and with a high-level of public input and interest. Implementation of the CMT required coordination of multiple contractors coupled with necessary compliance with extensive regulatory requirements. This has achieved a successful multi-method management test that included the herbicides endothall and triclopyr applied in a tank mix with Rhodamine WT dye, as well as UV-C light and combinations of herbicides and UV-C. These treatments were applied in three replicates per treatment, including control sites. Double turbidity curtains were installed at strategic locations to mitigate movement of herbicides or degradant to Lake Tahoe proper. In addition to the extensive water quality and aquatic plant monitoring, herbicide residues were monitored pre-treatment and several weeks after application. The results of the first year (2022) will determine where and how the second and third year will be conducted as non-herbicide treatments "Group B" methods. The Group B methods include diver-assisted suction removal, bottom barriers, UV-C light treatments. Monitoring will continue as in year 1; however, since no herbicides will be used in years 2 or 3, monitoring will not include monitoring for herbicides or degradants in the water.

10:50 – 11:10 **Controlling Aquatic Plants using Short Wavelength Ultraviolet Light**
John J. Paoluccio, Inventive Resources, Inc.

Abstract
Ultraviolet light in the germicidal range (UV-C) is a patented control method for treating aquatic weeds. Light rays in the 254nm to 275nm range can provide a lethal dose of radiation to damage the DNA of plant cells that prevents replication. The treated plants fall and start to die in a few days and decompose in a few weeks.
A power barge provides electrical power to a grid of UV-C lamps in a light array that is lowered over the plants. This consolidates the tall plants to shorten the distance between the plants and light rays. The closer the light rays can provide a lethal dose of radiation to control the plants.
Several pilot treatment projects up to 10 acres have been conducted with positive results.
UV-C Treatment has been shown to be a safe, practical and economical method of AIP treatment that can complement other treatment methods including hand pulling, bottom barriers, aeration and herbicides. Lake open waters, shallow areas, marinas and boat docks can benefit by combining certain treatment methods that can reduce cost and improve treatment.
An operator can control a power barge with a 16-ft x 40-ft light array and cover one half acre a day. The UV-C lamps have a service life of approximately 5,000 hours and require occasional cleaning.
https://www.iriproducts.com/UV/index.html

11:10 – 11:30 **Implementation of the Control Management Test (CMT) at the Tahoe Keys Lagoons, Part 2**
Toni Pennington, PhD, Environmental Science Associates

Abstract
The Tahoe Keys is a residential development in the south shore area of Lake Tahoe, CA consisting of approximately 1,500 homes and approximately 170 acres of waterways. The waterways are infested with

two non-native aquatic plants *Myriophyllum spicatum* (Eurasian watermilfoil) and *Potamogeton crispus* (curlyleaf pondweed) and one native, but nuisance species, *Ceratophyllum demersum* (coontail). Following implementation of the Tahoe Keys Control Methods Test (CMT) (see Zabaglo et al.), a number of approaches were used to evaluate the efficacy of the project to determine when and whether a 75% reduction was achieved for the target species. In addition to hydroacoustic scans conducted monthly, rake samples were evaluated for rake fullness, relative abundance of all plant species, frequency of occurrence, and plant health. Results of hydroacoustic scans indicate the greatest reductions in biovolume, when compared to the mean of three controls, occurred in sites treated with only endothall (whole plots or shoreline-only applications) and control was maintained through end of summer. Sites treated with triclopyr alone generally had lower biovolume compared to control sites, but the differences were not dramatic and varied greatly between replications. In UV-C only sites, substantial reductions were achieved in the days and weeks following treatments and, with re-treatments, biovolume was generally less than the control sites. We found a positive and significant correlation between percent biovolume from the hydroacoustic scans and rake fullness evaluations. To better understand treatment effects on the individual target species, the relative abundance of each was multiplied by the biovolume for each plot or the individual rake fullness metric. As expected, sites treated only with endothall was not highly selective for the target species; however, sites treated only with triclopyr were highly selective in controlling *M. spicatum.* Similar patterns were observed in the combination sites where only the shorelines were treated with herbicide. The UV-C only sites were most effective at controlling *M. spicatum*, to a lesser degree *P. crispus*, and far lesser to *C. demersum.* Plans for Year 2 are currently underway.

11:30 – 2:00 **Joint WAPMS-WSWS Awards Luncheon**
Boise Centre West Room 100B

Session F

2:15 – 3:15

2:15 – 2:35 **Translating Herbicide Use Pattern for Floating Plant Control with Spray Tracker Technology**

Jonathan Glueckert*[1], Amber Riner[2], James Leary[2], Alex Dew[3]; [1]University of Florida, Boynton Beach, FL, [2]University of Florida, Gainesville, FL, [3]Fish and Wildlife Conservation Commission, Tallahassee, FL

Abstract

Maintenance control of floating plants is a critical component of aquatic plant management (APM) programs on public lakes. The intent is to keep populations at low levels with frequent interventions using highly experienced, professional applicators trained to find small patches and precisely dispense small amounts of herbicide to targets while minimizing non-target injury. Maintenance control is a dynamic strategy that requires intense effort and is difficult to monitor. GPS fleet vehicle tracking technology was developed over two decades ago for commercial applications to monitor and evaluate transportation activities leading to many improvements in operational efficiency and cost reduction. GPS fleet tracking has recently been introduced to aquatic plant management on Florida public lakes with the advent of Spray Tracker technology providing real-time monitoring from a live web portal. The Spray Tracker device has an added feature of a spray valve actuator for signaling spray on/off to further display where and when herbicides have been applied. This operational data is downloadable in multiple forms including a comma separated value (.csv) format with georeferenced coordinates, time stamps and the added binary spray designation. Here, we build on this data by adding an attribute for how much herbicide was applied (i.e., active ingredient per unit area) when the sprayer was "on" by integrating sprayer calibration data (e.g., range and nozzle flow rate) and herbicide batch recipes. This gives a more spatially relevant account of how much (or little) herbicide is used in floating plant management. The adoption of this information technology is evidence to APM embracing the principles of precision pest management maximizing productivity, optimizing resources, and minimizing footprint.

2:35 – 2:55 **In-Stream Bioremediation Filters and E. coli Reduction**

Amy Kay, Partners of Scott County Watersheds, City of Davenport, IA

Abstract

Fecal pollution is a common water quality issue in many waterways of the United States. Partners of Scott County Watersheds (PSCW) in conjunction with the City of Davenport has strived to determine how to reduce e coli and hence fecal pollutions concentrations within the Duck Creek watershed and other streams. A pilot project was initiated that involved placing strips of floating island materials and building "biofilters" within small streams. Robin Creek, located in west-central Davenport, was selected as the location for the biofilter installation. Fifteen e coli samples were collected for analysis over a two year evaluation period. Upstream (untreated water) e coli sample results ranged from 57 to 17890 cfu/100 ml. Downstream samples ranged from 3 to 48840 cfu/100 ml. Twelve of the fifteen samples indicated a decrease in e coli concentrations, two showed increases, one sample indicated no change. Overall, the mean percentage reduction upstream to downstream over the evaluation period was 27.3%. Based on the measured total coliform and e coli data, there appears to be some influence on fecal bacteria by the biofilter assemblage.

2:55 – 3:15 **Developing Aerial Surveillance Methods for Identifying Cryptic Water Hyacinth (Eichhornia crassipes [Mart.] Solms) on Lake Lochloosa in Florida**

Amber Riner*, Jonathan Glueckert, James Leary, Amr Abd-Elrahman; University of Florida, Gainesville, FL

Abstract

Water Hyacinth (*Eichhornia crassipes* [Mart.] Solms) is an invasive, free-floating plant that has been managed in Florida for over a century. It is currently under statewide maintenance control to prevent small incipients from becoming large infestations. This requires an intense use of resources dedicated to monitoring and treatment efforts over large aquatic systems. This plant can migrate over long distances, colonize new areas and blend into native pad communities, making it difficult for an applicator to locate from a boat. The advent of small unmanned aerial systems (UAS) advances the opportunity for integrating aerial surveillance into the maintenance control of hyacinth. Affordable UAS outfitted with optical sensors and automated flight planning can cover large areas with high resolution imagery that is able to discriminate hyacinth from other species. We are testing this utility on Lake Lochloosa (2400 ha) with line point intercept missions capturing images from a nadir position at 1 cm resolution along transects that follow the littoral shoreline. We are learning that these missions are highly efficient, e.g., covering over 20 km and capturing over 900 images in less than 2 hours on the water. Each image can be manually scored with a presence/absence classification by an experienced analyst in less than 60 seconds and displayed in GIS for interpretation. To make this process even more efficient, we are integrating convolutional neural networks to automate the detection of hyacinth. In this presentation, we will discuss mission planning, image geo-referencing, model training and accuracy assessment. These technologies are accessible and user-friendly to practitioners with basic technical skills used in invasive plant management. The adoption of these technologies will greatly enhance intelligence that goes into management decisions for optimizing effort and resources.

3:15 – 3:30 **Break**

Session F

3:30 – 6:20

3:30 – 3:50 **Whole-genome Sequencing of an Herbicide Selection Experiment Identifies a Chromosomal Region Associated with Fluridone Resistance in Eurasian Watermilfoil**

Ryan Thum*[1], Gregory M. Chorak[2]; [1]Montana State University, Bozeman, MT, [2]Montana State University Department of Plant Science, Bozeman, MT

Abstract

A long-term goal of Eurasian watermilfoil management is to identify genes for herbicide resistance, so that genetic assays can distinguish susceptible versus resistant strains. We developed a genetic mapping

population for fluridone resistance by crossing a known resistant strain to a known susceptible strain. We identified resistant versus susceptible progeny from this cross by exposing them to 6 ppb fluridone for several weeks. Then, we performed whole-genome sequencing on the most resistant ('resistant bulk') and most susceptible ('susceptible bulk') progeny to compare DNA sequence variant frequencies across the genome between the two bulks. Using this approach, we identified a large-effect quantitative trait locus (QTL) – which essentially equates to a "resistance gene" – on one chromosome of the Eurasian watermilfoil genome. Interestingly, the gene for the phytoene desaturase enzyme – the molecular target for fluridone, and the basis for fluridone resistance in hydrilla – is not located on this chromosomal region. This indicates that structural mutation in the phytoene desaturase enzyme is not the mechanism of resistance for this strain, and instead suggests that the mechanism of resistance is related to either phytoene desaturase expression level, or non-target site resistance (e.g., fluridone metabolism). Ongoing research utilizes gene expression methods and further genetic mapping to test these hypotheses and narrow in on the causal mutation(s) for fluridone resistance in this small section of the genome. The identification of the QTL is a substantial step forward in the development of a specific genetic test for fluridone resistance. Such a test could allow large-scale genetic screening for fluridone resistance, and reduce the reliance on time-consuming, laborious, and cumbersome herbicide screens of every watermilfoil strain. More generally, our results illustrate that genomics and forward genetics approaches for non-model, aquatic weeds are increasingly feasible, and we encourage similar approaches in other managed aquatic plants.

3:50 – 4:10 **Spray Retention of Commonly Managed Invasive Emergent Aquatic Macrophytes**

Andrew W. Howell*[1], Erika J. Haug[2], Benjamin P. Sperry[3], Christopher R. Mudge[4], Robert J. Richardson[2], Kurt D. Getsinger[5]; [1]North Carolina State University, Pittsboro, NC, [2]North Carolina State University, Raleigh, NC, [3]US Army Corps of Engineers, Gainesville, FL, [4]U.S. Army Engineer Research & Development Center, Baton Rouge, LA, [5]US Army Corps of Engineers, Vicksburg, MS

Abstract

Invasive emergent and floating macrophytes can have detrimental impacts on aquatic ecosystems. Management of these aquatic weeds frequently relies upon foliar application techniques with aquatic herbicides. However, there is inherent variability of overspray (herbicide loss) for foliar applications into waters within and adjacent to the targeted treatment area. We evaluated the spray retention (herbicide captured) of four commonly managed invasive broadleaf emergent species: water hyacinth, alligatorweed, creeping water primrose, parrotfeather, and two emergent grass-like weeds: cattail and torpedograss. For all species, spray retention was simulated using foliar applications of rhodamine WT dye (RWT) as an herbicide surrogate under controlled mesocosm conditions. Applications were made via a CO2 pressurized backpack sprayer calibrated to deliver 935 L ha-1 of a 0.1% v/v RWT spray solution overtop outdoor mesocosms (OM) containing dense vegetation growth or no plants (positive control). Spray retention of the broadleaf species was further evaluated using similar methods in a CO2 pressurized spray chamber in a greenhouse (GH). Evaluation metrics included species-wise canopy cover and height influence on in-water RWT concentration using image analysis and modeling techniques. Results indicated spray retention was greatest for water hyacinth (OM: 76.1 ± 3.8, GH: 64.7 ± 7.4). Spray retention values were similar among the three sprawling marginal species alligatorweed (OM: 42 ± 5.7, GH: 37.5 ± 4.5), creeping water primrose (OM:52.7 ± 5.7, GH: 54.9 ± 7.2), and parrotfeather (OM: 47.2 ± 3.5, GH: 48.2 ± 2.3). Canopy cover and height were strongly correlated with spray retention for water hyacinth and sprawling marginal species. However, neither canopy cover nor plant height were effective predictors for grass-like species spray retention. Torpedograss and cattail, while similar in percent foliar coverage, differed in percent spray retention (OM: 8.5± 2.3 and 28.9 ±4.1, respectively). The upright leaf architecture of the grass-like species likely influenced the lower spray retention values in comparison to the broadleaf species.

4:10 – 4:30 **Alaska's First Invasive Aquatic Plant, Elodea**

J T Gravelie, Travis Fuller*, SePRO; Aditi Shenoy, Fairbanks Soil and Water Conservation District

Abstract

Short history of Elodea in Alaska and the inter-agency collaboration efforts. Specifically the work done by the Alaska DNR and Faribanks Soil and Water Conservation district utilizing SonarOne, a selective systemic aquatic herbicide. Treatment methods varied from liquid formulations to granular and the benefits of each method.

4:30 – 4:50 **A Centralized Database of Watermilfoil Strains Across the United States: Initial Insights, and Utility for Stakeholder Communication and Management Decision-Making**

Ryan Thum[1], Ashley L. Wolfe*[1], Raymond Newman[2]; [1]Montana State University, Bozeman, MT, [2]University of Minnesota, St. Paul, MN

Abstract

Watermilfoil strains, including Eurasian watermilfoil (*Myriophyllum spicatum*), native northern watermilfoil (*M. sibiricum*) and their hybrid offspring (*M. spicatum x M. sibiricum*), can differ in their growth, spread, impacts and herbicide response. Several watermilfoil strains (both Eurasian and hybrid) have been identified as resistant or susceptible to specific herbicides (e.g., fluridone). The ability to identify, and track known resistant and susceptible strains can inform managers as to whether a specific herbicide is appropriate for a particular strain. Herbicide response information is missing for many strains and tracking uncharacterized strains over space and time can inform the prioritization of strains to characterize. It also serves to connect stakeholders from different lakes to share their experiences. To track these strains, we created a centralized watermilfoil database. We have collated strain information from thousands of watermilfoil samples from across the United States sent to us by state agencies, aquatic plant management consultants and applicators, and citizen scientists. With this collation of strain information, we want to explore watermilfoil strain frequency and distribution patterns. We found three Eurasian watermilfoil strains that are common and geographically widespread across the United States. In contrast, hybrid watermilfoil strains have comparatively restricted geographic distributions. We did, however, find an exception to this with a known resistant hybrid watermilfoil strain found in multiple lakes within Michigan. When this database is publicly available, lake managers, property owners, and citizen scientists will be able to connect and pool efforts over shared strains within their lakes and effectively prioritized watermilfoil strain characterization.

4:50 – 6:20 **What's New in the Industry**

5:30 – 6:30 **Women of Aquatics ~ Happy Hour**

Bardenay Restaurant & Distillery - 610 W Grove St, Boise, ID

Thursday, March 2

WAPMS Sessions will be held in the Boise Centre West, Room 120A

Session G **WAPMS and WSWS Conference & Registration and CEU Sign-in**

8:00 – 12:00

8:00 – 9:30 **WAPMS Business Breakfast**

All WAPMS registered guests are invited to attend the breakfast and participate in the business meeting. Rooms 110A & 110B.

9:30 – 9:50 **Hydrilla Verticillata Phenology and Growth in Lotic Systems**

Jens P. Beets*[1], Erika J. Haug[1], Robert J. Richardson[1], Benjamin P. Sperry[2]; [1]North Carolina State University, Raleigh, NC, [2]US Army Corps of Engineers, Gainesville, FL

Abstract

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 sought to improve understanding of hydrilla present in flowing systems, with a comparison to a non-flowing system. Sites were selected on the Deep, Neuse, and Cape Fear Rivers of North Carolina, with three non-flowing reference sites on Lake Raleigh, NC. An analysis of current findings concerning differences in life stage, major phenological events, and biomass production will be provided. Differences in growth habit, sprouting, flowering, and timing of tuber production have been observed. This monitoring is also part of a collaboration with the University of Florida, with mirrored sampling and monitoring on dioecious hydrilla in Florida.

9:50 – 10:10 **The WeeDrone-120: Aquatic Maintenance Vessel**

Noah Williams*, Marketing at Seafloor Systems, Sacramento, CA; Dean Kinney, Senior Agronomic Sales Representative, Rocklin, CA

Abstract

The WeeDrone-120 is an Aquatic Maintenance Vessel that autonomously dispenses pesticides and herbicides into and along bodies of water. Once launched from the shore, the vessel navigates along the surface and applies liquid product remotely. This maximizes application efficiency, reduces exposure to chemicals, and provides total coverage to regain balance within water features.

Traditionally, pesticides and herbicides are applied to bodies of water by walking along the shore or getting in a manned boat to distribute product. These methods pose challenges, especially if the application area is large, or bordered by vegetation and mud. With the WeeDrone Aquatic Maintenance Vessel, the user can remain in one spot on the shore while the vessel does the work. Simply plan a mission with the included shoreside software, click 'Start', and let the vessel autonomously disburse product using GPS coordinates along the route. With an eight- hour run time and top speed of 3.5mph, the WeeDrone maximizes application efficiency in the field. Exposure to harmful chemicals is another factor that arises when using traditional chemical application methods. The more interaction points one has with chemicals, the higher risk there is of ingesting airborne particles and skin contact. With the WeeDrone-120, the risk of exposure is significantly decreased. Designed to carry two 2.5-gallon jugs of product, there is no need to measure out amounts prior to application. The sprayer system screws onto standard container spouts and dilutes the product using water from beneath the vessel. After the mission is complete, the jugs can be disposed in a safe place. Additionally, the three included sprayer heads enable the user to refine the best spray pattern for the environment. By limiting contact with chemicals, the WeeDrone heightens jobsite safety.

The WeeDrone-120 Aquatic Maintenance Vessel is ideal for the application of herbicides and pesticides, and with the option for remote controlled or autonomous -18 -operation, the vessel is convenient and easy to use. This remote application platform saves time, money, and provides total coverage to areas with problematic aquatic plants or pests. The WeeDrone is an efficient solution to regain and maintain balance within water features.

10:10 – 10:30 **Use of Unmanned Aerial Systems (Drone) Technology for the Control of Aquatic Vegetation in Hard to Access Sites**

Thomas J McNabb*, Clean Lakes, Inc. and Thomas Moorhouse, Clean Lakes, Inc., Coeur d'Alene, ID

Abstract

Various wetland, riverbank, and channel/canal sites have limited access for convention aquatic herbicide application equipment. With advancements in Unmanned Aerial System (UAS) Technologies, these sites

are now more accessible, and herbicide treatments can be performed more efficiently with increased control efficacy. The essential aspects of environmental and regulatory procedures for the use of UAS for herbicide applications will be reviewed, and well as some recent projects where treatment efficiency as well as control efficacy have been enhanced.

10:40 – 11:00 **Restoring Aquatic Ecosystems with Selective Herbicides and Phosphorus Mitigation Technology**

Kaitlyn H. Quincy*[1], Byran Fuhrmann[2]; [1]SePRO, Denver, CO, [2]SePRO, Whitakers, NC

Abstract

Aquatic plant management is important for ecosystem restoration, but can often have unintended consequences unless management is strategic. The use of herbicides to control aquatic plants typically leads to the release of nutrients during the decay of plant biomass. Contact, broad-spectrum herbicide application results in a rapid release of nutrients and the death of both native and invasive species. The presence of excess nutrients and the lack of competition from aquatic plants in the photic zone creates a niche that favors potentially toxic cyanobacteria.

This presentation will cover a combination of management techniques designed to effectively control invasive plants while minimizing the growth of cyanobacteria. These techniques include the use of systemic, selective herbicides which target invasive species while preserving native species and nutrient mitigation to sequester nutrients that are released. This talk will include research on methods to strategically combine systemic herbicides with nutrient mitigation tools for the best long-term outcome.

11:00 – 11:20 **Aquatic Photosynthetic Organisms**

Luke C. Huffman; University of Wisconsin, Madison, WI

Abstract

Hydrophytes, Seaweeds, and Allies: a whimsical guide to Aquatic Photosynthetic Organisms (APOs) is an informal textbook that I wrote to fill the gap of general misinformation on aquatic photosynthetic organisms, and lack of information to the general public. Much of the research going into it consisted of relevant semantics and taxonomy, ecological surveys, and basic demographic surveys. Additionally, I compiled a large amount of natural and cultural history from multiple sources on many of the aquatic plant families, genera, and species.

11:20 – 11:40 **Drawdown Applications of Three Acetolactase Synthase-Inhibiting Herbicides to Suppress Dioecious Hydrilla Tuber Sprouting**

Taylor L. Darnell[1], Candice M. Prince[2], Benjamin P. Sperry[3]; [1]Graduate Student, University of Florida Agronomy Department, Gainesville FL, [2]Assisstant Professor of Agronomy, University of Florida, Gainesville, FL, [3]Research Biologist, US Army Engineer Research & Development Center, Gainesville, FL

Abstract

Hydrilla [*Hydrilla verticillata* (L.f.) Royle] is a noxious aquatic weed belonging to the Hydrocharitaceae. This perennial species has a global distribution that is expanding rapidly. When left unmanaged, hydrilla forms dense monocultures that impede water movement. Hydrilla management has traditionally relied on in-water herbicide applications to control aboveground biomass but has not addressed the subterranean turion (tuber) bank. Previous research has shown that a properly timed drawdown can inhibit tuber formation. It was proposed that an artificial drawdown coupled with exposed sediment herbicide treatments would inhibit tuber sprouting. A mesocosm experiment was conducted to evaluate the efficacy of three ALS-inhibiting herbicide applications on hydrilla tuber sprouting control. The experiment was conducted twice with initial treatment dates of February 17, 2021, and April 26, 2021. Unsprouted hydrilla tubers were planted into plastic pots, immediately treated with bispyribac-sodium, penoxsulam, or imazamox at the maximum foliar rate. Herbicide was incorporated into the soil and pots were moved into a full-sun, open-air environment after treatment until placement in mesocosms (0, 1, 3, 7, 14, or 28 days). Due to interactions attributed to weather between runs, data were separated resulting in different trends in herbicide performance in a

dewatered setting. At 28 days to immersion (DTI), imazamox reduced biomass 97% followed by bispyribac (94%) and penoxsulam (65%) in late spring. In cooler temperatures, all herbicide treatments resulted in similar rates of control from 0 DTI to 14 DTI, but control was approximately 66% lower for bispyribac than either penoxsulam or imazamox treatments but has similar biomass reductions by 12 DTI. These data suggest that there is an opportune time to apply herbicides in a dewatered environment, but more research needs to be conducted to evaluate rates, timings to rewatering, and different chemistries.

11:40 – 12:00 **Clonal Diversity of Invasive Crested Floating Heart in the Southeastern United States**

Zachary J. Kuzniar*, Ryan A. Thum; Montana State University, Bozeman, MT

Abstract

Crested floating heart (*Nymphoides cristata*) is a relatively new aquatic invasive in the southeastern United States. The invasive potential of this species has been well documented in introduced areas but managing the growth and spread of populations remains a challenge. For clonal plants like crested floating heart, clonal diversity among populations may influence response to control tactics and/or the potential for local adaptation to environmental conditions. However, little is known about the diversity of introduced crested floating heart. In this study, we use genotyping-by-sequencing to determine how much clonal diversity is present in crested floating heart and how that diversity is distributed across the invaded range. Our results show that multiple, distinct clonal lineages of crested floating heart are present in the southeast. The geographic ranges of the lineages varied, with one widespread clone identified across several states and others only found in a single waterbody. There is also evidence of extensive asexual reproduction, with invaded waterbodies often host to a single clonal lineage. The clonal diversity reported in this study likely results from multiple introductions of crested floating heart to the southeastern U.S. and should be considered by managers and researchers when assessing control tactics (e.g. screening for biocontrol agents, herbicide testing) and studying the potential for spread or hybridization with native species.

Closing Remarks

Exhibitor Breakdown

Notes