40th Annual
Western Aquatic Plant Management Society
Annual Conference

March 8, 9 & 10, 2022

DoubleTree by Hilton Tucson - Reid Park, Tucson, Arizona

WWW.WAPMS.ORG

Past WAPMS Meetings Sites and Presidents

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

40th Annual
Western Aquatic Plant Management Society
Annual Conference

March 8, 9 & 10, 2022

DoubleTree by Hilton Tucson - Reid Park, Tucson, Arizona

PROGRAM

Tuesday, March 8

4:00 – 5:30	**Registration & Exhibition Set Up**
5:30 – 7:00	**President's Reception**

Wednesday, March 9

8:30 – 10:45	**Welcome to the WAPMS Conference, Updates, and Keynote Speakers**
8:30 – 8:45	**Welcome to the conference** President Cory Greer; Civil-Ag Engineer, USDA-NRCS, Wenatchee, WA
8:45 – 9:00	**Responsible Industry for a Sound Environment (RISE) Update** Megan Striegal; Manager, RISE, Arlington VA
9:00 – 9:15	**Aquatic Ecosystem Restoration Foundation (AERF) Update** Carlton Layne; Executive Director, AERF, Marietta, GA
9:15 – 9:30	**Women of Aquatics Update** Amy Kay; Clark, Oakwoods Hills, FL
9:30 – 10:00	**Staying Ahead of Risk: Salt River Project's Past and Future Water Management Legacy** Keynote Speaker Charles Ester III, Manager at Salt River Project (SRP), Phoenix, AZ
10:00 – 10:30	**How Drought on the Colorado River Impacts CAP Operations and Climate Adaptation Efforts** Keynote Speaker Donald Crandal, Water Control Manager, Central Arizona Project (CAP), Phoenix, AZ
10:30 – 10:45	Questions & Answers for the Keynote Speakers
10:45 – 11:10	**Break**

Session A

11:10 – 12:00

Control Options for Flowering Rush

11:10 – 11:35

Evaluation of Diquat for Control of Flowering Rush in High Water Exchange

Bradley T. Sartain[1], Kurt D. Getsinger[1], Damian J. Walter[2]
[1]US Army Corps of Engineers, Vicksburg, MS
[2]US Army Corps of Engineers, Walla Walla, WA

Abstract

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 l a 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 $p \leq 0.05$ 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.

11:35 – 12:00

Adaptive Management of Flowering Rush

Gray Turnage[1], John D. Byrd, Jr.[1], John D. Madsen[2], Ryan M. Wersal[3], Tera Guetter[4]
[1]Mississippi State University, Starkville, MS
[2]USDA-ARS, Davis, CA
[3]Minnesota State University, Mankato, Mankato, MN
[4]Pelican River Watershed District, Detroit Lakes, MN

Abstract

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.

12:00 – 1:30 **Lunch – On your own**

<u>Session B</u> Aquatic Weed Management in Irrigation Systems

1:30 – 3:35

1:30 – 1:55 **Vegetation Control at Central Arizona Project Intakes on Lake Havasu**

Scott Bryan, Sr Biologist, Cap Groundwater Management, Phoenix, AZ

Abstract

Since 2010, Central Arizona Project (CAP) has experienced an increase in problematic aquatic vegetation growth at its intakes on Lake Havasu. The vegetation can compromise the reliability and operations of the pumping plant and often requires mechanical removal. Currently, the vegetation is harvested using a weed boat, but this collection method is costly and time-consuming. Automated mechanical removal using a trash rake system was attempted in 2016, but proved to be ineffective as the primary solution. In May 2019, a pilot study was conducted using an herbicide application (Endothall) to determine its effectiveness in controlling vegetation growth within CAP's intake channel. Use of copper-based products in the past were largely unsuccessful, but the pilot endothall treatment completely eradicated vegetation in a 5-acre test plot. However, subsequent endothall treatments in 2020 and 2021 provided mixed results, as pondweed species were effectively controlled, but naiad species were largely unaffected by the treatment. Moving forward, CAP will continue to harvest vegetation within the intake channel, but will focus chemical treatment on areas where pondweed growth is dominant to reduce the mechanical removal efforts.

1:55 – 2:20 **SRP Aquatic Weed Control Utilizing White Amur, Herbicides and Mechanical Methods**

Brian Moorehead, Sr Biologist, SRP Groundwater Division, Phoenix, AZ

Abstract

Salt River Project began using White Amur (grass carp) in 1990 as a means of improving aquatic vegetation control, lowering costs and moving to a more environmentally friendly weed control program. White amur usage was expanded over time to allow construction and installation of fish grates during the annual dry up of canal sections and to spread the cost of new structures over time. The last major expansion was completed in 2005 and incorporated 129 miles of the 131-mile canal system. Although herbicide usage was discontinued in the canal system, SRP does continue to utilize herbicides in the smaller laterals where the size of the white amur and number of delivery gates makes further expansion unfeasible; and lower flow rates help reduce herbicide volumes and costs. Copper based herbicides replaced acrolein in 2011 and an endothall based product was added to the product list. SRP had a long history of utilizing mechanical vegetation removal which was mostly replaced by the fish and chemical products. However, chain demossing was necessary in early summer of 2021 following losses of white amur due to high storm flows in late summer of 2020. Excavator removal of vegetation still occurs in the laterals, but usually is secondary to the need for silt removal.

2:20 – 2:45 **Challenges and Solutions to Controlling Aquatic Vegetation in the South Columbia Basin Irrigation District**

Matt Morgan, Aquatic Program Manager, South Columbia Basin Irrigation District, Pasco, WA

Abstract
The South Columbia Basin Irrigation District (SCBID) is located in eastern Washington State and is one of three Districts comprising the Columbia Basin Project (CBP). The SCBID delivers water to over 230,000 acres of land through a vast network of canals and laterals. Aquatic plants can take up large amounts of space in irrigation canals, slowing the flow of water and causing the water level to raise. If not properly managed, these aquatic plants can make it impossible to meet demand and provide sufficient water to landowners. Filamentous algae form dense mats on the water surface and within the water column. These algae mats break off and flow downstream clogging infrastructure such as intakes, screens and weed racks.

Landowners within the SCBID use the water for purposes such as fruit, grain, vegetable and melon farming among others. This creates challenges because there are only a handful of approved aquatic pesticides that do not harm any of these commodities at effective treatment rates. With over 1,000 miles open of ditch, pesticides are the most practical option for controlling aquatic vegetation. However, the biggest challenge to effective control is the fact that unused water returns to the receiving water body at various locations called compliance points. The receiving water body in the case of SCBID is the Columbia River.

The compliance points are located within the irrigation system, slightly upstream from the Columbia River. The Irrigation System Aquatic Weed Control General Permit issued by the Washington State Department of Ecology determines the effluent limits. The exact concentration depends on the specific chemical and is derived from toxicology studies involving sensitive species. For example, SCBID typically applies acrolein in the range of 1 ppm to 4 ppm within the irrigation system. However, the concentration of acrolein at any compliance point cannot exceed 0.021 ppm. SCBID employs a variety of strategies to ensure compliance including pesticide choice, tracking and monitoring, operational procedures, and data acquisition technology. The SCBID continues to work to find a variety of solutions to ensure that pesticides can be used in the most effective and environmentally friendly manner in order to continue providing sufficient water to productive lands.

2:45 – 3:10 **Idaho Water Resource Board Projects**
Brian Olmstead, Idaho Water Resource Board, Twin Falls, Idaho

Abstract
The Idaho Water Resource Board consists of 8 members, representing different water basins in Idaho and appointed by the Governor. We are tasked by the State Legislature with implementing the State Water Plan, financing water projects, and operating programs that support sustainable management of Idaho's water resources. Idaho is very much a desert state, with most of our crop growing areas averaging less than 10 inches of precipitation annually so water is truly the "life blood" that drives our State economy!

My presentation will highlight several of the ongoing programs, and new water projects that the IWRB is currently working on. These programs include: 1- A very aggressive and productive cloud-seeding program that we operate in partnership with Idaho Power Company throughout most of the State's stream basins; 2- A major managed aquifer recharge program on the Eastern Snake Plain Aquifer, that supports almost 2 million acres of irrigated cropland; Minimum stream flow programs in several of Idaho's rivers that support recovery efforts for anadromous fish (salmon) and other endangered aquatic species; 4- a revolving loan program that supports Irrigation Districts and other Water Users in their water conservation efforts and in rehabilitating aging infrastructure on their systems ; 5- A Flood Management Program to help Flood Control Districts, Municipalities, and others to prevent and mitigate damage to flood prone areas.

New water projects that the IWRB is currently working on include: 1- Raising Anderson Ranch Dam on the Boise River to store 30,000 acre/feet of additional multi-purpose water for the rapidly growing Boise area. This is a joint project with the Bureau of Reclamation and is being financed using a combination of WINN Act, ARPA, and State funds; 2- Building a 12 mile pipeline from the Snake River to the Mountain Home Air Base to insure enough water to support current and future needs for military operations there; 3- Construction of new outlet works and boat throughfare at Priest Lake in the Idaho Panhandle to enhance recreation opportunities and support sport fisheries in that watershed.

3:10 – 3:35 **Real-time tracking of Algaecides in Water Supply Canals**
Justin Pascual, Associate Water Resources Specialist, Solano County Water Agency

Abstract
The Solano County Water Agency (SCWA) is a regional wholesale water supplier, providing municipal and agricultural water to over 400,000 residents and over 75,000 acres of irrigated land in Solano County, California. Solano County is located halfway between San Francisco and Sacramento and encompasses portions of the urban San Francisco Bay Area as well as the agriculturally productive Sacramento Valley. Water is supplied to the region by the federally owned and locally managed U.S. Bureau of Reclamation (USBR) Solano Project. A key feature of the Solano Project and the focus of this study, is the 33-mile concrete-lined Putah South Canal (PSC), providing municipal and agricultural water across Solano County.

Like many canals across the western United States, the PSC encounters significant growth of filamentous algae, diatoms, and macrophytes that can impact flow conveyance and clog intakes. To manage algae, diatoms, and to a lesser extent macrophytes, copper sulfate has been the historic product of choice. However, due to high levels of alkalinity and the increased presence of macrophytes, there is significant interest in using other more effective algaecides in the PSC. However, since the PSC is a major municipal water supply, California regulators require the use of NSF-60 certified algaecides or the ability to obtain a waiver for a non-certified algaecide.

To help meet this regulatory requirement, SCWA and our partner operator the Solano Irrigation District (SID) have conducted numerous trials using strongly chelated copper algaecides in SID's ag laterals. Furthermore, a series of water quality sondes were installed along the laterals. For each algaecide application, Rhodamine Dye was used as a real-time surrogate for the various copper algaecides. In addition, similar trials using an NSF-60 certified Rhodamine Dye with copper sulfate were done in the PSC. Throughout all the trials, discrete grab samples were collected and analyzed for copper concentrations using both field test kits as well as laboratory analysis. The results for the various field trials and algaecides show that the real-time water quality sondes do an excellent job of tracking the copper plumes, predicting transport times, as well as estimating copper concentrations. During several of the PSC trials, SCWA used telemetered sondes, and was able to post the data online in real-time for direct use by the canal operators, water treatment operators, and other interested staff. While these trials were specific to the PSC, they could easily be implemented on any other canal system where algaecides are actively used.

3:45 – 4:00 **Break**

<u>Session C</u> **Controlling Harmful Algae Blooms**

4:00 – 5:25

4:00 – 4:25 **Mitigating Harmful Algae Blooms (HAB) in Washington Lakes, Operational Experiences**
Terry McNabb, Certified Lake Manager; Trent Shelton, Fisheries Biologist

Abstract
Harmful algae blooms are an increasing problem in our nation's waters. These cyanobacteria species produce both acute and chronic toxins that pose a threat to wildlife, pets and humans that live near and utilize these waterbodies.

There are two approaches to managing HAB blooms.

Reactive strategies are a useful tool to restore the beneficial used of these systems. We have used Peroxygen algaecides effectively when a response is needed. One case study will be presented where a northwest City was hosting it's first Ironman Competition and a toxic algae bloom was detected five days prior to the event. Mobilizing and applying a Peroxygen algaecide removed the threat and the event was able to utilize the lake.

Phosphorus sequestration will probably play a more important role in managing these HAB problems however. Cyanobacteria can fix nitrogen from the atmosphere and have a competitive advantage when phosphorus levels are high. The use of lanthanum technology to sequester and remove phosphorus from water column and mitigate release from the lake sediments provides long term relief from HAB conditions. A second case study will be presented where lanthanum modified clay was used in a prescription over two summers to provide HAB free conditions.

4:25 – 4:50 **Use of Peroxyacetic Acid (PPA)/Hydrogen Peroxide in Freshwater Cyanobacterial Control – Case Study of Lab Scale Trials in Relation to Field Treatment**

Tom Warmuth, Sr Sales Representative, BioSafe Systems, East Hartford, CT

Abstract

Peroxide based algaecide have been shown effective in selective treatments for cyanobacteria. Lab scale trails of liquid Peroxyacetic acid (PAA)/hydrogen peroxide and solid SCP (sodium carbonate peroxyhydrate) on *Microcystis aeruginosa* give direction on developing effective dosing in field applications for cyanobacterial harmful algal blooms (cHAB). Monitoring prior to treatment the bloom density and distribution provide guidance for effective timing and method/technique of application adjusting for cell density at depth with algaecide concentration.

4:50 – 5:15 **Impact of Harmful Algae Blooms on Fish and Water Use**

Justin Nawrocki, Sr Sales Representative, United Phosphorus, Ltd, King of Prussia, PA

Abstract

The frequency and longevity of harmful algae blooms (HABs) appears to be on the rise with several recent cases gaining national spotlight. In August of 2014 a bloom in Lake Erie shut down the water supply to Toledo for nearly a week. The largest fish kill in North Carolina history was due to an alum treatment that occurred to sequester nutrients feeding a bloom. Lastly Lake Okeechobee has been experiencing yearly HAB issues in recent history. When toxins are produced by HABs it can have serious acute and chronic outcomes affecting the delicate ecological balance of these water-bodies. This presentation will give a general background on the ecological toll on both humans and aquatic organisms due to harmful algae blooms.

6:00 – 6:30 **Cocktail Reception**

6:30 – 8:00 **WAPMS Awards Dinner**

Thursday, March 10

<u>Session D</u>

8:00 – 9:40

8:00 – 8:25 **Trials to Evaluate "Natural" Herbicides for Aquatic Weed Management**

Lyn A. Gettys, University of Florida, Davie, FL

Abstract

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.

8:25 – 8:50 **Herbicide Activity Dynamics of Foliar Applications to Waterhyacinth**

Benjamin P. Sperry[1], Candice M. Prince[2], Jason Ferrell[2]
[1]US Army Corps of Engineers, Gainesville, FL
[2]University of Florida, Gainesville, FL

Abstract
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.

8:50 – 9:15 **Herbicide Spray Loss and Retention: Influence of Floating Plant Density, Carrier Volume and Adjuvants**

Christopher R. Mudge[1], Benjamin P. Sperry[2], Kurt D. Getsinger[3]
[1]US Army Corps of Engineers, Baton Rouge, LA
[2]US Army Corps of Engineers, Gainesville, FL 3US Army Corps of Engineers, Vicksburg, MS

Abstract
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 (ED_{50}) was 32, 62, and 55 PAC for water hyacinth, water lettuce, and giant salvinia, respectively. Greater

ED_{50} 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.

9:15 – 9:40 **Evaluation of florpyrauxifen-benzyl to control invasive macrophytes in the United States and New Zealand**

Andrew W. Howell1, Deborah E. Hofstra[2], Mark A. Heilman[2], and Robert J. Richardson[2]
[1]North Carolina State University, Pittsboro, NC
[2]North Carolina State University, Raleigh, NC

Abstract

Invasive aquatic plants continually threaten freshwaters worldwide. While biological and physical control measures are utilized, targeted invasive weed removal programs regularly deploy chemical control measures. The registration of the auxin herbicide, florpyrauxifen-benzyl, in the United States provides water resource managers with another herbicide for weed control. Currently, available aquatic herbicides do not control weed species with consistency and there is limited control data for many problem species. Research was conducted in North Carolina and New Zealand to evaluate submersed and foliar applications of florpyrauxifen-benzyl to expand current control tactics of coontail [*Ceratophyllum demersum* L.], oxygen weed [*Lagarosiphon major* (Ridley) Moss], Brazilian elodea [*Egeria densa* Planch.], parrotfeather *[Myriophyllum aquaticum* (Vell.) Verdc.], and alligatorweed *[Alternanthera philoxeroides*(Mart.) Griseb.] Results for the submersed plants indicate 30 $\mu g\ L^{-1}$ florpyrauxifen-benzyl provided CC_{80} (80 % control compared to untreated control group) of *L. major* and *E. densa* (4 and 7 WAT, respectively). Emergent plant studies indicate single foliar applications of florpyrauxifen-benzyl provide >90% parrotfeather control 4 and 8 weeks after treatment (WAT) at rates $\geq$ 29.4 g a.i. ha^{-1}. Alligatorweed was less sensitive than parrotfeather at rates tested and repeat applications were necessary to achieve >94% control 12 WAT. Future work should evaluate the selectivity of florpyrauxifen-benzyl against potentially sensitive native plants and designate the appropriate contact times required for operational control in field settings. Foliar combination studies screening tank mix partners that provide effective alligatorweed control with a single florpyrauxifen-benzyl treatment would further benefit water resource managers.

9:40 – 10:05 **Break**

Session E

10:05 – 11:45

10:05 – 10:30 **Evaluation of two florpyrauxifen-benzyl formulations and rates for control of water hyacinth (*Eichhornia crassipes*) in mesocosm settings**

Gray Turnage[1], Christopher R. Mudge[2], and Mike D. Netherland[3]
[2]US Army Corps of Engineers, Baton Rouge, LA
[3]Research Biologist (deceased), U.S. Army Engineer Research and Development Center, Environmental Laboratory, Gainesville, FL

Abstract

For over a century, the invasive floating plant water hyacinth [*Eichhornia crassipes* (Mart.) Solms] has negatively impacted waterbodies throughout the southern U.S. from California to Florida. Auxinic herbicides are one of the mainstays used to control floating, emergent and submersed vegetation. In the U.S., florpyrauxifen-benzyl, a synthetic auxin, was registered in 2018 for aquatic use, but limited information has been published on efficacy and differences between the two formulations. Since only one formulation of florpyrauxifen-benzyl is registered per state (suspension concentrate (SC) in the southeastern states and emulsifiable concentrate (EC) elsewhere) and no control data have been published to confirm use rates referenced on labels, it is important to determine the efficacy of both formulations on this species so that resource managers across the U.S. will know which herbicide rate to use with the herbicide formulation available to them. Therefore, small-scale research was conducted in Louisiana and Mississippi to evaluate the SC and EC formulations of florpyrauxifen-benzyl at 14.8, 29.5, and 58.9 g ai ha^{-1} against water hyacinth under outdoor and greenhouse conditions. All rates of each florpyrauxifen-benzyl formulation reduced water hyacinth biomass by 90% to 100% when compared with nontreated plants at 5 weeks after treatment. Based on plant recovery in the outdoor trial (Louisiana), there was some evidence that the lowest rate (14.8 g ai ha^{-1}) of florpyrauxifen-benzyl SC and EC may not be as efficacious at reducing water hyacinth biomass as the SC and EC formulations when applied at 29.5 and 58.9 g ai ha^{-1}. However, there were no differences among the treatments in the greenhouse trial in Mississippi. These findings support the use of florpyrauxifen-benzyl for the control of water hyacinth regardless of formulation.

10:30 – 10:55 **Flumioxazin + Imazamox Total Vegetation Management**

K. George Beck, PhD Market Development Specialist, Alligare, LLC

Abstract

Flumioxazin is a PPO inhibitor that controls over 90 weeds and is registered for use in many crops, aquatic weed control, and to maintain total vegetation management. Flumioxazin is used primarily to control annual weeds and mixed with other herbicides that have longer soil residual to extend bare ground control for several months. Recently, Alligare conducted cooperative research in North Carolina and California to test the viability of flumioxazin + imazamox for bare ground control. Performance in both locations was outstanding; in North Carolina, flumioxazin + imazamox at all rates tested controlled 98-100% of henbit (*Lamium amplexicaule*), smallflower buttercup (*Ranunculus abortivus*), common mouse-ear chickweed (*Cerastium fontanum*), and wall speedwell (*Veronica arvensis*) for 137 days after application that produced 95-100% bare ground over that time period. Research was conducted at UC-Davis where hare barley (*Hordeum murinum*), annual bluegrass (*Poa annua*), Italian ryegrass (*Lolium multiflorum*), wild oat (*Avena fatua*), soft chess (*Bromus hordeaceus*), burclover (*Medicago polymorpha*), whitestem filaree (*Erodium moschatum*), common mallow (*Malva neglecta*), and shepherdspurse (*Capsella bursa-pastoris*) comprised the vegetation for the second bare ground study. Vegetation was divided into total grasses and burclover for evaluation as well as an estimate of bare ground for 2, 3, and 4 months after treatments (MAT) were applied. Flumioxazin + imazamox at 12+32 and 12+64 fl oz/A produced 93 and 96% bare ground and only 6 and 4% cover of grasses at 2 MAT. Flumioxazin + imazamox at 3 MAT displayed 98 and 99% bare ground; both treatments allowed 0.3-1.5% cover of grasses and burclover whereas bare ground and grass cover by isoxaben + dithiopyr at 31+32 fl oz/A were 47 and 49%, respectively. By 4 MAT, isoxaben + dithiopyr produced only 16% bare ground and grass cover was 77%, while flumioxazin + imazamox at 12 + 64 fl oz/A still maintained 93% bare ground, less than 1% grass cover, and 7% burclover cover. Bare ground had decreased to 75% in flumioxazin + imazamox treated plots at 12+32 fl oz/A with burclover as the primary cause for the decrease showing 23% cover. Data from the North Carolina and California studies clearly show excellent performance from flumioxazin + imazamox, particularly at 12 + 64 fl oz/A.

10:55 – 11:20 **Hydrilla Response to Intermittent-Pulse Herbicide Treatments**

Taylor L. Darnell[1], Candice M. Prince[1], Benjamin P. Sperry[2]
[1]Agronomy Department, Center for Aquatic and Invasive Plants, University of Florida
[2]Research Biologist, US Army Engineer Research and Development Center

Abstract

Hydrilla [*Hydrilla verticillata* (L.f.) Royle] is one of the most troublesome submersed aquatic weeds in the US. Registered herbicide options are limited in aquatic systems. Therefore, optimizing available herbicide efficacy is paramount to improved hydrilla management. A potential option for herbicide optimization is through an application technique termed “intermittent-pulse” exposure where an active herbicide exposure time precedes a rest phase (no herbicide present) followed by an active herbicide exposure. This “on/off/on” regime has varied exposure times for the initial treatment, rest phase, and final treatments to maximize herbicide efficacy. However, little is known of the appropriate initial, rest, and final exposure time requirements for success. The dipotassium salt of endothall was used as the active ingredient due to its widespread use for hydrilla management, especially in flowing water scenarios. Consequently, small-scale mesocosm experiments were conducted to evaluate the effects of varying intermittent-pulse exposures of the dipotassium salt formulation of endothall for hydrilla control. The current research aimed to evaluate the effect of varying initial and final herbicide treatment times and the effect of a varying rest phase on reducing hydrilla biomass. All three experiments were set up as completely randomized designs with five replicates. Results indicated that an initial exposure duration (2, 4, 8, or 12 hour) influenced biomass reduction less than other application technique components. Percent biomass reduction of pulsed herbicide treatments showed that a 2-, 4-, 8-, and 12-hour initial exposure reduced biomass by 80, 71, 62, and 83 %, respectively, compared to the control. However, biomass was reduced 78, 52, and 30% compared to the nontreated control from 16-, 40-, and 64-hour rest phases, respectively. Static herbicide treatments resulted in more consistent biomass reduction compared to pulsed treatments. Pulsed herbicide applications may have the ability to reduce hydrilla biomass more effectively than conventional herbicide applications, but further work to refine an initial treatment, rest phase, and final treatment scheme is required before recommending this treatment regime.

11:20 – 11:45 **The Ecology of Submersed Aquatic Vegetation Communities under Management in Select Florida Lakes**

Jacob Thayer, James Leary, Candice Prince, and Kelli Gladding
University of Florida, Gainesville, FL

Abstract
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.

11:45 – 1:15 **Lunch on your own, AERF hosted lunch for Students**

Session F

1:15 – 2:45 **WAPMS Business Meeting and Program**

1:15 – 1:30 **WAPMS Business Meeting**

1:30 – 1:55 **Using genetics to quantify clonal diversity in irrigation canal weed populations**

Zachary J. Kuzniar, Ryan A. Thum
Montana State University

Abstract
Agricultural production in the western United States is dependent on an extensive network of canals for irrigation water delivery. Managing these water conveyance networks includes control of aquatic weeds that negatively impact canal structure and function. Herbicides are the primary tool for canal weed control, but regulatory constraints limit the number of active ingredients available to managers. As such, many canal plant populations are consistently and repeatedly exposed to the same herbicide, which raises concerns about the probability of herbicide resistance.

Determining whether and to what extent herbicide resistance threatens canal systems requires the development of bioassays to identify susceptibility versus resistance. While bioassays for sexually reproducing plants are often performed at the population level, herbicide bioassays for asexual plants may be more appropriately conducted at the clonal (biotype, or strain) level. However, many aquatic weeds are capable of both sexual and asexual reproduction - the dominant mode of reproduction for irrigation canal weeds remains unclear. The lack of previous work on canal weeds leaves a fundamental question unanswered: what is the appropriate biological unit for herbicide bioassays (populations versus clones)?

To answer this question, we employed a population genetic approach to describe the reproductive biology of Zannichellia palustris (horned pondweed), a common nuisance aquatic plant found in canal systems. Samples were collected from twelve irrigation canal sites across Oregon, Idaho, Montana, and Utah. Genotyping-by-sequencing was used to estimate clonal diversity within and among populations of horned pondweed. Results from this work will be discussed as implications for herbicide resistance screening, particularly in the development of bioassays used to test herbicide response in different clones or populations from sites of interest.

1:55 – 2:20 **Glyphosate: Facts and Fiction**

J. Ferrell, University of Florida, Gainesville, FL

Abstract
Glyphosate remains the most commonly used herbicide in the world, but in recent years it has gained significant notoriety for its potential adverse health effects on humans. This started in 2015 when the International Agency for Research on Cancer published a report classifying glyphosate as a Type-2A Probable Carcinogen. Since this time, multiple nations have conducted independent analysis of these same data but have failed to draw similar conclusions. Meanwhile, this change in classification sparked a class-action lawsuit that drew over 90,000 plaintiffs in the United States. These cases, being tried in Civil Court, resulted in multi-million-dollar verdicts in first three trials. Based on the total number of cases waiting on the docket and the result of the three guilty verdicts, Bayer chose to settle these cases in a near $10 billion payout. Not all plaintiffs accepted this settlement and the cases continue to be tried in civil courts.

2:20 – 2:45 **Establishing a model system to examine eutrophication and invasion effects on wetland nutrient mitigation**

Andrew Sample[1], Gary Ervin[1], Gray Turnage[2]
[1]Mississippi State University, Department of Biological Sciences
[2]Mississippi State University, Geosystems Research Institute

Abstract
Increased nutrient inputs into the Mississippi River resulting from extensive agricultural activity and loss of wetlands can be mitigated via wetland restoration initiatives. The goal of this study is to improve restoration initiatives by establishing a model system for exploring effects of species invasion and eutrophication on floodplain wetlands in the southeastern US. Two regionally non-weedy emergent macrophyte species—*Juncus effusus* (Common Rush) and *Schoenoplectus tabernaemontani* (Softstem Bulrush)—and two common weedy emergent macrophyte species—*Typha latifolia* (Broadleaf Cattail) and *Phragmites australis* (Common Reed)—were chosen as model species for these studies. The first year of this multi-year mesocosm study was aimed at determining baseline growth and nutrient removal from the water column for each species, in monoculture, under a standardized flooding and nutrient availability regimen. Results from

the first year showed clear differences in growth patterns between the weedy and non-weedy species. As expected, the weedy species exhibited faster radial spread and reached taller maximum heights than the non-weedy species. The non-weedy species also showed relatively consistent growth rates through the growing season, whereas the weedy species displayed relatively short bursts of rapid growth prior to flowering. Despite those differences in growth, we saw no differences in nutrient removal from the water column based on species or species designation (weedy or non-weedy). Follow up work will include simulated scenarios of species invasion (monoculture and mixed culture mesocosms) and eutrophication (mixed culture mesocosms with baseline and increased nitrogen concentrations). This study should provide insight for aquatic resource managers and restoration practitioners regarding project species selection and for planning adaptive management strategies in the face of two major challenges to managing wetlands and other aquatic resources.

2:45 – 3:10 **Break**

Session G — Unmanned Air and Water Application Equipment

3:10 – 4:50

3:10 – 3:35 **Unmanned Aerial Application Systems for Aquatic Plant Control: Case Studies in North Carolina**

Andrew W. Howell[1] and Dr. Robert J Richardson[1]
[1] North Carolina State University, Pittsboro, NC

Abstract

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 discussed to determine application tactics for floating plant control.

3:35 – 4:00 **The Seafloor WeeDrone Aquatic Maintenance Vessel**

Eric Ray, Marketing Director, Seafloor Systems, Shingle Springs, CA

Abstract

The Seafloor WeeDrone 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. Although not eliminated, the risk of exposure is significantly decreased when using the WeeDrone Aquatic Maintenance Vessel. 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 Aquatic Maintenance Vessel is ideal for the application of herbicides and pesticides, and with the option for remote controlled or autonomous 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.

4:00 – 4:25 **Development of Novel Autonomous Aquatic Pesticide Application Systems (ADAPT)**

Justin Nawrocki, Sr Sales Representative, United Phosphorous Limited, King of Prussia, PA

Abstract

Aquatic vegetation surveys and aquatic herbicide applications are integral components of vegetation management programs that protect water resources. However, surveys and herbicide applications can be labor intensive and provide opportunities for introducing cost saving measures. The goal of this project was to design, prototype, and demonstrate a small fleet of autonomous aquatic vehicles (AAVs) capable of detecting, quantifying, and selectively applying herbicide to manage invasive aquatic weed infestations. To date, four AAVs have been developed to evaluate performance, durability, and operational capacity. Field testing of these units has been conducted. Utilization of a trolling motor provided approximately 9x increased thrust over an air propeller and also improved turning radius. Incorporation of a lithium iron phosphate battery significantly reduced weight and increased carrying capacity while also allowing for rapid charging. Autonomous tracking of two AAVs concurrently has been implemented and demonstrated. Successful collection of hydroacoustic data as well as herbicide application through the AAVs has also been verified. Real world evaluations with professional applicators have been completed which facilitated improvements in the current design, which are now commercially available.

4:25 – 4:50 **Panel Discussion: Unmanned mobile technology advances for aquatic plant management**

Andrew Howell[1], Gray Turnage[2], Eric Ray[3], Justin Newrocki[4]

[1] North Carolina State University, Pittsboro, NC

[2] Mississippi State University, Geosystems Research Institute

[3] Marketing Director, Seafloor Systems, Shingle Springs, CA

[4] Sr Sales Representative, United Phosphorous Limited, King of Prussia, PA

Abstract

Advances in unmanned mobile applications and by air and boat provide managers with passive assessments which improve time and labor effort, increased survey accuracy, and repeatable measurements. Discussion will include an overview and examples of:

I. Web/Desktop Scouting

- i. FREE GIS Tactics
- ii. Satellite Imagery

II. Field-based Recordings

i. Mobile Imagery and Applications
ii. Echosounding (Sonar) Systems
iii. Unmanned Aerial Systems (sUAS)

III. AI & Autonomous Management Strategies

i. sUAS and Drone Boats
ii. Computer Vision

Closing Remarks

Exhibitor Breakdown

Notes