

## **UMISC 2020 Abstract Book**

Abstracts appear in the same order as listed in the agenda

### **MONDAY MORNING CONCURRENT SESSIONS**

#### **Adaptive Management in Action**

##### **Revising Minnesota's Invasive Species Management Plan: What Are Your Thoughts?**

*Chelsey Blanke<sup>\*1</sup>, James Calkins<sup>2</sup>, Doug Jensen<sup>3</sup>, Byron Karns<sup>4</sup>, Sascha Lodge<sup>1</sup>, Cori Mattke<sup>5</sup>, Kelly Pennington<sup>1</sup>, Katie Sickmann<sup>6</sup>; <sup>1</sup> Minnesota Department of Natural Resources; <sup>2</sup> Minnesota Nursery and Landscape Association; <sup>3</sup> University of Minnesota Sea Grant Program; <sup>4</sup> National Park Service - St. Croix National Scenic Riverway; <sup>5</sup> Minnesota Aquatic Invasive Species Research Center; <sup>6</sup> St. Croix River Association*

The Minnesota Department of Natural Resources (DNR) Invasive Species Program has been working to improve trade-pathway invasive species prevention. Global trade drives invasive species introductions to Minnesota and the United States. The horticulture, pet, food, bait, and classroom and laboratory biological supply trades are some of the known pathways for invasive species. In recent years, DNR staff has been working to assess invasive species risks associated with each of these trades and develop relationships with business owners and industry. An assessment of pathways revealed that about 2/3 of Minnesota prohibited invasive species, those that are illegal to possess and sell, have been documented in the trades listed above (42 species). Additionally, 3/4 of Minnesota regulated invasive species have been documented in these trades (15 species). In collaboration with the University of Minnesota Sea Grant Program, DNR staff developed and distributed guidance for reducing risk of invasive species introduction through trade pathways. We also surveyed Minnesota businesses about their concerns, knowledge and business practices related to invasive species prevention and management. Ongoing work aims to identify and reduce trade-pathway invasive species risks through the development of partnerships and breaking down barriers to invasive species prevention best practices.

##### **Development, Implementation, & Evaluation of Michigan's Red Swamp Crayfish Adaptive Response Plan**

*Lucas Nathan<sup>\*1</sup>, Seth Herbst<sup>1</sup>, Brian Roth<sup>2</sup>, Kelley Smith<sup>2</sup>, Sara Thomas<sup>1</sup>; <sup>1</sup> Michigan Department of Natural Resources; <sup>2</sup> Michigan State University*

Applying an adaptive management approach when responding to invasive species can provide a framework for identifying and reducing key uncertainties. The Michigan Department of Natural Resources (MDNR) was notified of the first documented population of invasive red swamp crayfish (*Procambarus clarkii*) in Michigan in July 2017. To address the threat, MDNR partnered with Michigan State University to develop a red swamp crayfish response plan. The plan emphasizes an adaptive approach through an iterative evaluation of response efforts. Active collaborations among universities, state and federal agencies, stakeholder groups, and tribal strike teams increases state-wide capacity and allows for a more comprehensive response strategy. The collective efforts have included pathway-based risk assessments, targeted surveillance for new infestations, an evaluation of source populations, extensive mechanical removals via trapping, development and evaluation of novel control alternatives, and chemical treatments. Trapping data from 2017-2020 has been used to address critical uncertainties including detection probability of surveillance methods using occupancy models, mechanical removal efficacy and abundance estimation using N-mixture models, and multi-gear comparisons of size- and sex-specific trapping biases. New information gained during the 2020 response efforts will be incorporated into the future strategy to continuously improve the effectiveness of the ongoing response to red swamp crayfish.

## **Using Impact Collaborative Innovation to Forecast Terrestrial Invasive Species Priorities in Minnesota**

*Matthew Russell<sup>\*1</sup>, Angela Gupta<sup>2</sup>, Regina McGoff<sup>2</sup>; <sup>1</sup> University of Minnesota; <sup>2</sup> University of Minnesota Extension*

Outreach programs in invasive species can be innovative or not. Educational programs can deliver programs to existing audiences in familiar ways (a status quo approach) or can offer new programs to new audiences (an innovative approach). In 2020, the University of Minnesota Extension used principles from the Impact Collaborative Innovation Kit developed by eXtension and other techniques to identify priority programming around terrestrial invasive species issues in Minnesota. This process involved preparatory work by participants to question-storm and ideate on terrestrial invasive species topics. Question-storming and ideating occurred via online questionnaires and provided a diversity of viewpoints and perspectives on priority issues. The process concluded with a half-day workshop in January 2020 that brought together 25 terrestrial invasive species leaders in the state to sort ideas into themes. Themes were expressed as simplified statements which provided a broad goal with achievable impacts within a one-year time frame. Impacts from the workshop promoted cross-agency collaborations with identified priorities for terrestrial invasive species issues. This presentation will share our experiences in developing and delivering the workshop, share evaluation results of the process, and discuss successes of the work in prioritizing terrestrial invasive species issues in Minnesota.

## **AIS Rapid Response in Pennsylvania: Case studies of Successes and Lessons Learned**

*Sara Stahlman, Pennsylvania Sea Grant*

When aquatic invasive species (AIS) prevention efforts fail, it is critical that a structure be in place to quickly and effectively address new infestations before they have an opportunity to establish and spread. The development of the Pennsylvania AIS rapid response plan was led by Pennsylvania Sea Grant and approved by the Governor's Invasive Species Council of Pennsylvania in September 2014. Since that time, Pennsylvania Sea Grant has worked to streamline and improve this process through the development of mock rapid response exercises and trainings for state agencies and organizations involved with invasive species. Feedback from these exercises has led to an updated and improved rapid response plan which includes funding strategies, permitting, working on private lands, and case studies detailing specific successes and sticking points within the process. This presentation will review the rapid response process in Pennsylvania and highlight specific rapid response examples that have utilized the process to respond to real infestations. It will discuss successes agencies and organizations have accomplished, while also identifying gaps and challenges within the process and how these barriers were overcome. The information presented may assist other regions in developing or informing their own rapid response efforts.

## **Novel Detections: eDNA & Other Strategies - Part 1**

### **AIS and Boating Access Sites: A Study of Michigan's Inland Lakes**

*Christina Baugher, Michigan Department of Natural Resources*

Michigan has over 1,200 public boating access sites and approximately 750,000 registered recreational watercraft. It is known that AIS are spread through the boating pathway, but data about AIS presence at access sites had never been collected on a statewide scale. A pilot project was completed in 2019 to better understand AIS abundance at public access sites, and by extension, what a boat or trailer may snag during launch or retrieval and subsequently spread. 157 boating access sites were surveyed for ten submerged and shoreline AIS using rake tosses and visual observation. Approximately 45% of the access sites did not have any target AIS present, and nearly 80% of launch lanes either had no vegetation or it was sparse. Eurasian watermilfoil was the most

common AIS detected, found at 34% of sites. Detection probabilities were not statistically different for either rake toss location (dock vs. shore) or target species. Also, native plants were consistently found alongside AIS, with no monocultures detected. There may be a trend with larger access sites (determined by number of launch lanes) having more AIS present, but additional sites would need to be surveyed to confirm. This project provided a quick snapshot of what was present at the DNR's boating access sites, and resulting management actions and future projects will be discussed during this presentation.

### **Sampling Design for Early Detection of Invasive Plants in Great Lakes Ports**

*Andrew Tucker<sup>\*1</sup>, Lindsay Chadderton<sup>1</sup>, Erick Elgin<sup>2</sup>, Gust Annis<sup>1</sup>, Joel Hoffman<sup>3</sup>; <sup>1</sup>The Nature Conservancy; <sup>2</sup>Michigan State University Extension; <sup>3</sup>U.S. Environmental Protection Agency Office of Research and Development*

At least sixty-five aquatic plant species have been identified as part of a "watch list" of non-native species that pose a threat to Great Lakes biodiversity and ecosystem function. Early detection of these potentially invasive aquatic plants (IAP) in Great Lakes ports could minimize impacts of novel incursions and facilitate successful eradication. We developed, implemented, and then adaptively refined a probabilistic boat-based sampling design for surveying aquatic plant communities in large (1000+ acres) Great Lakes coastal areas. Surveys were conducted from 2017 to 2019 at three Great Lakes locations - Milwaukee (WI), Cleveland (OH), and the Detroit River (MI). More than sixty aquatic plant species were collected from across the three sites. One-fifth of the species were non-native to the Great Lakes basin. Sample-based species rarefaction curves, constructed from detection data from all surveys combined at each location, show that the estimated sample effort required for high confidence (>95%) detection of rare, including potentially invasive, species varies (< 40 sample units for Detroit River; >170 sample units for Milwaukee). During a standard three-day survey effort 40 to 60 sample units were surveyed at each location. Levering information on detection patterns from initial surveys, including depth and species richness strata, improved survey efficiency and completeness in subsequent surveys. Under the optimized survey designs, at least 90% of the estimated species pool was detected during a typical three-day survey. The survey design we describe provides a useful template that could be adaptively improved for early detection of IAP in the Great Lakes.

### **DNA Meta-Barcoding-Based Identification of Fish Larvae for Invasive Species Early Detection**

*Joel Hoffman<sup>\*1</sup>, Christy Meredith<sup>2</sup>, Erik Pilgrim<sup>1</sup>, Anett Trebitz<sup>1</sup>, Chelsea Hatzenbuehler<sup>1</sup>, John Russell Kelly<sup>1</sup>; <sup>1</sup>U.S. Environmental Protection Agency Office of Research and Development; <sup>2</sup>Montana Department of Environmental Quality*

When initially introduced, invasive species typically evade detection because they are present at low density and occupy a small area; DNA metabarcoding (i.e., DNA barcoding coupled with high-throughput sequencing, or HTS) may be both more sensitive and accurate than morphology-based taxonomy, and thus has the potential to increase detection of rare or invasive species. We quantified the relative error of species presence results between morphology-based and HTS-based taxonomic identification of ichthyoplankton collections from the Port of Duluth, Minnesota, an aquatic non-native species introduction "hot-spot" in the Laurentian Great Lakes, and compared HTS-based detection to existing early detection surveys. We found high agreement between methods at the system scale; HTS-based taxonomy identified 28 species, morphology-based taxonomy 30 species, and 27 of those were common to both. Among samples, 76% of family-level taxonomic assignments agreed; however, only 42% of species assignments agreed. Most errors were attributed to morphology-based taxonomy limitations (yielding false negatives, 9%) and species misidentification (which yields false positives, 20%, and false negatives, 21%), whereas HTS-based taxonomy error was low (5%). Further, the probability of detecting most of the non-native fishes as larvae in a randomized survey was roughly similar to the probability of detecting them as juveniles or adults in a survey optimized for non-native species early detection. We

conclude that as a first step toward incorporating HTS-based taxonomy into large-scale surveys for non-native species early detection, benchmarking HTS results against traditional, morphology-based taxonomy is important to quantify error rates and determine error sources.

### **Aquatic Invasive Species Aerial Detection Pilot Project**

*Tony Brough, Hennepin County, Minnesota, James Hughes, Hughes Company Innovations, and Laetitia Moreau*

Aquatic Invasive Species (AIS) Aerial Detection Pilot Project, is an innovative project utilizing an unmanned aerial system (UAS/aka drone). The project tests the hypothesis; can a UAS equipped with high-resolution electro-optical and multispectral sensors bring fundamentally new and valuable perspectives to help with invasive species early identification, rapid response, and management. The project features a test location of approximately 50 acres of Medicine Lake in Hennepin County, MN. This lake is known to have Eurasian Watermilfoil, Curly-Leaf Pondweed, and Starry Stonewort. The project schedule is designed to capture imagery of Eurasian Watermilfoil, Curly-Leaf Pondweed, and Starry Stonewort at their zenith during the 2020 open water season. The UAS captures high-resolution imagery in visible and near-infrared parts of the electromagnetic spectrum. This imagery allows for the creation of vegetation indices, such as the normalized difference vegetation index (NDVI), which are used to help identify and delineate the aquatic vegetation. In this presentation, we will discuss challenges, technical aspects, and practical considerations of using UAS for aquatic vegetation monitoring. We will also share some of the detailed results which include a resolution less than .5 inch per pixel, electro-optical and multispectral orthomosaic maps that identify and delineate lake vegetation. Our initial testing cycles have revealed some promising results. We look forward to sharing our findings and conclusions with the group.

### **Survey 123 for Fisheries Data Collection: Benefits Realized and Lessons Learned**

*Grace Loppnow, U.S. Fish and Wildlife Service*

Digital field data collection saves time and reduces error when compared to using paper datasheets. However, transitioning from paper to digital presents challenges to both the data manager and field biologist, especially given the large volume of data and unpredictable field conditions endemic to fisheries. The U.S. Fish and Wildlife Service's AIS Early Detection and Monitoring Program is transitioning from traditional paper-based data collection to digital data collection using ESRI's Survey 123 for ArcGIS app. In this talk, I will discuss the benefits of digital data collection, recommendations on how to transition from paper to digital, and lessons learned from practical application.

## **Control of Floating-Leaf & Emergent Invasive Plants**

### **Update on Promising Biological Control Options for Flowering Rush (*Butomus umbellatus*)**

*Jennifer Andreas<sup>\*1</sup>, Patrick Haefliger<sup>2</sup>, Harriet Hinz<sup>2</sup>; <sup>1</sup> University of Washington Extension; <sup>2</sup> CABI*

Flowering rush (*Butomus umbellatus*) is a perennial aquatic plant of European origin that was introduced to North America as an ornamental over 100 years ago. Biological control of this plant is very promising, because *Butomus umbellatus* is the only species in the family *Butomaceae* which increases the likelihood of finding host-specific biological control agents. We have currently prioritized three candidate agents. The weevil *Bagous nodulosus* was tested for oviposition (egg-laying) on 45 test plant species and eggs were found only once on one non-target species. Larval no-choice establishment tests are also confirming that the weevil is highly host-

specific. In impact experiments, adult feeding reduced above-ground biomass of flowering rush by 33%, and below-ground biomass was decreased by 50% on plants exposed to adults. We plan to prepare the petition for field release in winter 2020/21. The agromyzid fly *Phytoliriomyza ornata* is another promising agent that can cause plants to wilt after only three days exposure to a single female. Host-specificity tests are underway. Finally, the white smut *Doassansia niesslii* is being studied. The overwintering state of the smut infests plants under water, which will be very advantageous for completely submerged infestations of flowering rush. However, the strains found so far in Germany and France only attack a rare genotype of flowering rush in Canada. Therefore, we need to search for strains infesting the most common genotypes in North America. Identifying the origin of the invasive North American populations of flowering rush is expected to help.

### **The Phenology of Flowering Rush (*Butomus umbellatus*) in the Western United States**

*John Madsen\**, USDA - Agricultural Research Service, Kurt Getsinger, U.S. Army - Engineer Research and Development Center

Flowering rush (*Butomus umbellatus* L.) is an invasive aquatic plant with western infestations in Montana, Idaho, and Washington. We are examining the phenology of this species in two separate studies. In the first study, we established plants from populations in western Montana, eastern Idaho, and northwestern Minnesota in a common garden area at the Davis, CA research facility to compare seasonal growth of separate populations in a common environment. Plant height and phenological characteristics were measured weekly, and biomass samples were collected monthly from each population for a two year period. No growth differences between populations were detected. Shoot growth was initiated in March, and senescence began in September. Rhizome bud formation began in June, and ceases in September. In the second study, we collect biomass samples from three locations (Idaho panhandle, western Montana, and eastern Idaho) four times a year (spring, early summer, late summer, fall) for two years. Bud densities range from 500 to 1200 rhizome buds per square meter, which translates to between 2 and 5 million buds per acre. Growth was evident from June through August. The results of this study are consistent with those of a phenology study on Detroit Lake, Minnesota. The goal of long-term management, at least for triploid flowering rush, should be to prevent rhizome bud formation and deplete the rhizome bud bank.

### **European Frogbit - An Emerging Concern in the Great Lakes Region**

*Mark Warman\** and Jennifer Hillmer, Cleveland Metroparks

Miniature lily pads of European frogbit (*Hydrocharis morsus-ranae*) first escaped in the 1930s from an experimental farm in Ottawa, Canada and have been detected at a rapid pace in the last ten years. Over 4,000 observations of European frogbit have been recorded in Michigan, Ohio, New York, and Ontario since 2010. With record high water levels in the Great Lakes system European frogbit has been predictably pushed inland, to new habitats. Plants have also been discovered in unexpected places: isolated waterbodies, state parks and wildlife preserves, and sites several counties away from any known infestation. The speedy expansion of European frogbit territory is a concerning development for all Great Lakes states. Cleveland Metroparks will present on the recent discoveries, early detection methods, and an overview of management techniques.

### ***Glyceria maxima* (Gly-max) Eradication in a Wisconsin Lacustrine Wetland**

*Kyle Duquaine*, Eco-Resource Consulting, Inc.

Wetlands across the Midwest are in danger of being dominated by invasive wetland vegetation such reed canary grass (*Phalaris arundinacea*) and reed mannagrass (*Glyceria maxima*). Eco-Resource Consulting, Inc. (ERC) provides science-based ecological guidance and sustainable restoration to reconstruct native wetlands and help

stop the spread of aquatic invasive species across the Midwest. One of our many wetland restoration projects is in Waukesha County, Wisconsin. The wetland under review is a combination of forested wetland, emergent wetland and wet sedge meadow that was dominated by reed mannagrass and reed canary grass prior to the onset of restoration. Following comprehensive wetland functionality assessment in 2014 restoration actions commenced in 2015 with broad scale herbicide applications. Aquatic-approved Glyphosate (Aquaneat) and Imazapyr (Polaris) were both utilized for two applications per year for four years. The wetland was then seeded with native wetland vegetation after the aquatic invasive species were under control. Soon after the herbicide treatments, native wetland species such as Joe pye weed (*Eutrochium purpureum*), prairie cordgrass (*Spartina pectinata*), lake sedge (*Carex lacustris*), softstem bulrush (*Schoenoplectus tabernaemontani*), woolgrass (*Scirpus cyperinus*) and marsh milkweed (*Asclepias incarnata*) began to recover and push back into the wetland to reclaim the areas they lost to the Gly-max. Bur reed (*Sparganium americanum*) was also planted as plugs in 2019 to fill the niche that was previously filled by the Gly-max. In 2018, prescribed fire was first introduced into the restoration areas to further suppression of invasive species and to encourage the development of native plant communities. The wetland has slowly returned to a thriving aquatic ecosystem that provides water quality improvements, wildlife habitat and flood protection.

### **Successful Removal of Yellow Floating Heart (*Nymphoides peltata*)**

*Chris Hamerla, Golden Sands RC&D Council, Inc.*

Manual removal can be a successful tool to reduce or eliminate invasive species from waterbodies, wetlands and terrestrial sites. Traditionally, expensive chemical herbicides are used to manage invasive species populations. However early or scattered populations can often be controlled by manual removal for a lower cost, with minimal or no non-target impacts to the ecosystem and in areas where herbicides aren't an option. Additionally, this technique can also be used along with herbicide control and as follow up to a treatment. Manual removal can be effective on a variety of invasive species. This presentation will highlight the successful removal of yellow floating heart (*Nymphoides peltata*) from Gordon Lake, northern Wisconsin.

## **Jumping Worms: New Research & Outreach**

### **Jumping Worms: Impacts, Identification, Actions, and Public Outreach**

*Laura Van Riper\*, Minnesota Department of Natural Resources, Angela Gupta, University of Minnesota Extension*

The term "jumping worms" refers to multiple species of worms in the *Amyntas* and *Metaphire* genera. These worms are getting lots of attention for their startling movements and their impacts in gardens and forests. Jumping worms can dramatically change soils, giving it a unique texture similar to coffee grounds. Jumping worms feast on mulch and strip vital nutrients from topsoil. This kills plants and increases erosion. Homeowners may see garden plants killed and may have difficulty growing plants. Foresters and land managers may see changes to the plant and animal communities in forests. This presentation will discuss impacts of jumping worms, how to identify jumping worms, known current distribution, and regulatory updates. Learn about actions that land managers and homeowners can take to prevent, report, and manage jumping worms. Also, learn about some of the outreach that's happened and surprising audience responses. Could jumping worms be the poster child for invasive species vectors?

## **Jumping Worms: Become a Worm Ranger!**

*Ryan Hueffmeier\* and Stephan Carlson, University of Minnesota*

Jumping worms are the latest invasive worm to arrive in Minnesota. They live in the top few inches of soil and alter soil structure and chemistry through their feeding and burrowing behaviors. Found in garden beds, mulch and compost piles they represent a threat to the health of our managed and wild landscapes. This presentation will focus on the creation of a citizen scientist network of Worm Rangers investigating their distribution and dispersal mechanisms throughout Minnesota. Jumping worms are spread through composting, horticulture, landscaping and bait. The overall goal of this project is to characterize the status of the jumping worm invasion in Minnesota. A network of Worm Rangers will be created utilizing a diverse group of Minnesota citizen scientists through the Master Gardener and Master Naturalist programs. This project will focus on four regions: Rochester, Twin Cities, St. Cloud and Duluth. You will be trained to look at their distribution and dispersal. Other UMISC jumping worm talks will focus on the natural limitations and prospects for management of this early stage invasion. Exploring your yard and gardens is key! Join this workshop to learn more about them and how to collect data. If you suspect you have jumping worms take a photo. You can still participate this fall along with the 2021 growing season.

## **Jumping Worms - Ecology and Management Research**

*Lee Frelich\*, Yoo Kyungsoo, Tyler Baumann, Shuai Yang, Erin Bucholz, University of Minnesota*

This project is characterizing the incipient invasion of jumping earthworms (*Amyntas* spp., originating from Asia) in Minnesota. We have set up observational field experiments to examine population dynamics and rate of spread of jumping worms as affected by: (1) habitat type (forest, mulched garden beds, lawns), (2) food quality (leaf litter from deciduous versus coniferous overstory vegetation), (3) soil temperature and moisture, and (4) topography of the landscape. We hypothesize that jumping worms spread faster in shaded or mulched habitats, but that sunny habitats where the top soil is warm and dry at midsummer (e.g. open lawns) are obstacles to their spread. A second hypothesis related to spread of jumping worms is that they exhibit long-distance, human-aided spread related to movement of mulch and nursery stock. A second aspect of the project is to examine how jumping worms interact with the pre-existing European earthworm invasion, testing the hypothesis that jumping worms displace the European species *Lumbricus terrestris*, because they compete for the same food source, but that endogeic European earthworm species (e.g. *Aporrectodea* spp.) remain in deeper soil layers. We also test the hypothesis that jumping worm invasion accompanies substantial changes in soil morphology. A third aspect of the project will examine potential to control jumping worm populations, via lab experiments and field trials with environmentally friendly chemicals such as saponins. Finally, lab experiments will examine low-temperature tolerance of jumping worm eggs to see whether winter soil temperatures in Minnesota are a limiting factor in their spread.

## **Response of two Pheretimid Earthworms, *Amyntas tokioensis* and *A. agrestis*, to Different Litter Types**

*Bradley Herrick\* and Marie Johnston, University of Wisconsin - Madison Arboretum*

Asian pheretimid earthworms transform soils, nutrient dynamics, soil food webs, and surface litter in temperate forests and horticultural landscapes of the United States. While these earthworms are often found in forests dominated by *Acer saccharum*, earthworm response to different litter types is unclear. A 95-day mesocosm study was designed to test the consumption, productivity, fitness, and fecundity of *Amyntas agrestis* and *A. tokioensis*. Earthworms had contact with one of five litter treatments: maple (*A. saccharum*), oak (*Quercus alba* and *Q. macrocarpa*), pine (*Pinus strobus*), pooled native C4 prairie grasses, or none (soil only). Earthworm mass, cocoon count, dry litter mass, and the C:N ratio of litter and soil were collected every three weeks. Both species *A. agrestis* and *A. tokioensis* lost body mass at the end of 95 days compared to starting

weight, regardless of litter type. Across all mesocosms, *A. agrestis* experienced greater mortality than *A. tokioensis*. *Amyntas tokioensis* had the greatest survival rate when in the presence of maple litter. Overall, *A. tokioensis* produced 340 total cocoons while *A. agrestis* produced 60 ( $P=0.0126$ ). Of these, *A. tokioensis* produced 233 and 79 cocoons in the maple and oak litter treatments respectively. Litter consumption and C:N ratio of litter and soil were highly variable across treatments. Our results suggest that *A. tokioensis* may survive and produce cocoons in the presence of sugar maple litter and to a lesser extent in oak litter. These data will help evaluate the potential risk of *A. tokioensis* and *A. agrestis* invasion in different habitats.

## **Invasive Plant Genetics & Implications for Management**

### **Diversity and Introgression of Knotweed (*Fallopia* spp.) in Minnesota**

Dallas Drazan\*, Alan Smith, Neil Anderson, Roger Becker, Matt Clark, Andrzej Noyszewski, Marie Abbey;  
University of Minnesota

Knotweed (*Fallopia* spp.) is a highly competitive, invasive herbaceous perennial that has spread from its native range in Japan, China, and Korea to Europe and then to North America. It was first introduced to the United States in 1873 and was sold as an ornamental plant in Minnesota by 1908. The knotweed complex includes Japanese knotweed (*Fallopia japonica*), a dwarf-type Japanese knotweed (*F. japonica* 'Compacta'), giant knotweed (*F. sachalinensis*), and their hybrid, Bohemian knotweed (*Fallopia x bohemica*). Knotweed can spread asexually by rhizomes and adventitious rooting, and sexually. The hybrid is difficult to distinguish from the parents and each can respond differently to control methods. This research aims to genetically identify the species composition of knotweed in Minnesota. A preliminary genetic analysis accurately identified and distinguished individuals. Surprisingly, Japanese individuals showed genetic diversity despite being sold as a strictly clonal species. DNA sequencing will provide improved species identification and targeted treatments for land managers to select the most effective treatment method. The level of introgression among the knotweed complex will be determined to measure how hybridization can lead to increased levels of genetic diversity and ability to adapt to differing environments and management measures. This research aims to use DNA markers to determine if knotweed populations spread by asexual or sexual propagation. Knowing how knotweed is spreading will allow land managers to better combat its dispersal.

### **Improvements in Genetic Testing for the Identification of Palmer Amaranth in Seed Mixtures**

Anthony Brusa<sup>\*1</sup>, Eric Patterson<sup>2</sup>, Todd Gaines<sup>3</sup>, Philip Westra<sup>3</sup>, Don Wyse<sup>1</sup>; <sup>1</sup> University of Minnesota; <sup>2</sup> University of Michigan; <sup>3</sup> Colorado State University

*A. palmeri* is an aggressive and prolific weed species that has major ecological and economic impacts on agricultural row cropping systems. Using morphological identification to distinguish *A. palmeri* from other *Amaranthus* species is difficult, which has led to the use of genetic testing becoming the standard for *Amaranthus* species identification. We have developed an improved genetic test to maximize the robustness and reliability of *A. palmeri* identification. We assembled a large and geographically diverse panel of *Amaranthus* accessions and utilized Genotyping by Sequencing (GBS) to identify novel species-specific single nucleotide polymorphisms (SNPs) from these populations. These diagnostic SNPs were then used to develop a genotyping assays through Kompetitive Allele Specific PCR (KASP). Performance was assessed against a validation panel of 1,250 *Amaranthus* individuals of 9 species.

The end result is a set of three KASP assays for identification of *A. palmeri*, for use either independently or in conjunction. Assays were tested against the most robust validation panel of *Amaranthus* individuals in publication thus far, and demonstrated an accuracy of 99.7-99.9% on single sample validations. Diagnostic



statistics and confusion matrices are presented. Additionally, these markers were tested for sensitivity by extracting *A. palmeri* seeds in combination with seeds from Tall Waterhemp (*A. tuberculatus*). All three markers are capable of reliably detecting a single *A. palmeri* seed in a pool of 200 *Amaranthus* sp. seeds ( $p < 0.0001$ ). Our work represents an improvement over existing commercial assays in terms of sensitivity, robustness of validation, and ease of use.

### **Regional Patterns of Reed Canarygrass (*Phalaris arundinacea* L.) Genetic Structure along Six Major Minnesota Rivers**

*Andrzej Noyszewski*<sup>\*1</sup>, *Neil Anderson*<sup>1</sup>, *Alan Smith*<sup>1</sup>, *Andrzej Killan*<sup>2</sup>, *Diana Dalbotten*<sup>3</sup>, *Emi Ito*<sup>1</sup>; <sup>1</sup> University of Minnesota; <sup>2</sup> Diversity Arrays Technology; <sup>3</sup> St. Anthony Falls Laboratory

Reed canarygrass (RCG) is commonly found as an invasive and native grass in Minnesota wetlands and along river banks. Its native status for populations along rivers, in wet meadows, and cultivated fields was recently established with molecular studies. This study measures the genetic composition of wild RCG populations using samples collected along six major Minnesota rivers: Mississippi, Minnesota, LaCroix, Red, Des Moines, and Roseau every 30 km (with additional collections within major collection sites). Genetic diversity was estimated for 737 RCG genotypes from 68 major locations and was measured using 2,493 polymorphic DArTseqLD SNP (single nucleotide polymorphisms) markers. Population genetic structure was determined using STRUCTURE cluster analysis and showed diverse genetic composition for each of MN rivers. The number of predicted clusters ranged from  $k = 2$  (Minnesota river) to  $k = 32$  (Upper Mississippi River). This means that 2-32+ genetic variants were present within each river, some of which were shared among rivers. Minnesota river RCG populations are complex and distinct for each river system. Our results provide critical genetic information for RCG that can guide management decisions, mainly since the effectiveness of the control method(s) may be genotype-specific. We recommend that, if this native grass is to be managed, that RCG be managed as multiple populations for each MN river.

### **Trait Based Approach Showing Variations of Reed Canarygrass along Urbanization Gradient**

*Leah Weston*<sup>\*1</sup>, *Charles Day*<sup>2</sup>, *Stephen Hovick*<sup>1</sup>; <sup>1</sup> The Ohio State University; <sup>2</sup> Cornell University

Urban wetlands are exposed to a variety of anthropogenic impacts that may hinder ecosystem function. In particular, salt from winter road de-icing and metals accumulate more in urban wetlands compared to wetlands surrounded by natural land use. These stressors can negatively impact native plant communities and contribute to invasive species establishment. Reed canarygrass (*Phalaris arundinacea*) is an invasive wetland grass found across North America that has been shown to be mildly salt tolerant and variably tolerant to metal contamination. Reed canarygrass is highly variable, thus urban populations could adapt in the presence of anthropogenic stressors. We quantified responses to salt, copper and zinc addition by reed canarygrass collected from four populations spanning an urbanization gradient (natural, rural, moderate urban and intense urban), based on surrounding land use. We measured ten morphological above and belowground traits, testing for trait and trait plasticity differences based on source population, treatment, and their interaction. Overall, treatments negatively affected seven traits compared to control. Four traits varied by source population. Plasticity, or the difference in trait values between a plant under control vs. stressed conditions, varied by source population for six traits. A principal component analysis incorporating all trait measurements revealed distinct differences between the natural and intense urban source populations, demonstrating these two populations have inherently different adaptive strategies across treatments. These results demonstrate the between population variability in reed canarygrass and the differential sensitivity to stress in populations across an urbanization gradient.

## MONDAY AFTERNOON CONCURRENT SESSIONS

### Unique Outreach for Unique Audiences

#### **Don't Pack a Pest for Academic Travelers - Minnesota**

*Doug Jensen<sup>\*1</sup>, John Vreyens<sup>2</sup>, Sam Chan<sup>3</sup>, Tania Siemens<sup>3</sup>; <sup>1</sup> University of Minnesota Sea Grant Program; <sup>2</sup> University of Minnesota Extension Global Initiatives; <sup>3</sup> Oregon State University Sea Grant Extension*

Academic travelers need to be better educated to help protect our country's crops, forests, livestock and natural resources by preventing prohibited animals and plants and food, agricultural and animal products that can harbor devastating pests and diseases being carried into the U.S. Started in 1991, the Don't Pack a Pest (DPAP) campaign is now a partnership between the U.S. Department of Agriculture, U.S. Homeland Security/Customs and Border Protection, and State Departments of Agriculture. Just last year, there were 66,000 violations by academic travelers. Oregon Sea Grant recently developed a new research-based approach to improve outreach for international and study abroad students and teaching and research faculty. With generous support of University of Minnesota Twin Cities international and study abroad administrators, student focus groups created journey story maps to help inform us about critical control points for intervention.

Following the Oregon-based model, Minnesota Sea Grant and Extension's Global Initiatives received funding to develop Minnesota into a pilot regional hub. Now as a partner, our team is reaching out to contacts at Duluth, Morris and Crookston campuses to invite them to support DPAP development within their institutions. With their support, our objective is to co-host six student focus groups at each campus for outbound study abroad and incoming international students. Data gathered will help to raise awareness of risk aversion behaviors for packing luggage through educational tools developed in collaboration with University faculty, staff and students. Come learn about our approach intended to institutionalize DPAP messaging into international study and research programs.

#### **A Survey of Practitioners of Buddhist "Life Release" Residing in the United States and how such Information may lead to Reducing Invasion Risk**

*Tim Campbell<sup>\*1</sup>, Bret Shaw<sup>2</sup>, Evelyn Hammond<sup>3</sup>, Luye Bao<sup>2</sup>, Shiyu Yang<sup>2</sup>, Peter Jurich<sup>2</sup>; <sup>1</sup> University of Wisconsin Sea Grant; <sup>2</sup> University of Wisconsin Department of Life Science Communication; <sup>3</sup> University of Wisconsin Division of Extension*

The Buddhist practice of life release consists of freeing animals condemned to die in order to obtain merit. While it is known invasion pathway in some Asian counties, little is known about the status of this practice in the United States. With funding from the Mississippi River Basin Aquatic Nuisance Species Panel, we interviewed Buddhists within the Mississippi River Basin who have practiced life release. These interviews, along with the results of a Chinese and English language literature review, allowed us to develop a better understanding when the practice occurs, what organisms are released, what the motivations behind the practice are, and how these communities would welcome engagement from natural resource managers. Additionally, we surveyed natural resources managers across the United States to determine what practices that meet the intent of life release they would be comfortable with, and to learn more on how they think they could engage life release practitioners. Using the combined results, we will recommend an engagement strategy that can help life release practitioners meet the intent of their practice while minimizing the risk of aquatic invasive species introduction.

## **Invasive Species Outreach to Waterfowl Hunters and Furbearer Trappers**

*Chris Hamerla, Golden Sands RC&D Council, Inc.*

Angler and boater awareness of invasive species has greatly increased with outreach programs and messages such as Stop Aquatic Hitchhikers!, Clean Boats Clean Waters and Clean, Drain, Dry. Waterfowl hunters and furbearer trappers require a modified approach to invasive species outreach but can be significant partners towards invasive species prevention and detection. Much of the angler/boater outreach has been designed to engage people from Memorial Day to Labor Day. Other user groups use their watercraft and equipment from October through April. It is very likely that many hunters and trappers are also anglers or summer boaters but they might not think of invasive species while in the field later in the season. Others may only use their boat/equipment during that time of year and may not have been exposed to the Stop Aquatic Hitchhikers! message. By varying existing outreach methods and creating new resources Golden Sands RC&D Council, Inc. in cooperation with WI Waterfowl Association, WI Trappers Association and the Wisconsin Aquatic Invasive Species partnership has started reaching thousands of new people through print media, video and by one-on-one contacts. Hunting and trapping access points are highly variable and typically random at best so interactions are best during scheduled events like banquets, rendezvous, youth events and required safety courses. While these events are valuable for teaching how to prevent the spread of aquatic invasive species they are also great opportunities to teach identification of invasives to help with early detection monitoring.

## **Managing Aquatic Plants Together: Programs and Policies to Support Collaborative Natural Resource Management**

*Alison Mikulyuk\*, Madison Johansen, Michelle Nault; Wisconsin Department of Natural Resources*

Wisconsin's approach to aquatic plant management strives to balance the needs of different stakeholder groups with protecting the ecological value of aquatic plant communities. Regulations and permitting combined with financial and technical assistance work together to support local groups in their attempts to manage aquatic plant communities while ensuring their lakes, rivers and wetlands remain as healthy as possible. We will introduce several complementary programs and policies that make up the aquatic plant management program in Wisconsin, highlighting how a group can successfully navigate the program in pursuit of their management goals.

## **Fostering Informed Consumers of Aquatic Invasive Species Management**

*Megan Weber\*, Daniel Larkin, Patrick Mulcahy; University of Minnesota*

Pesticide education has typically focused on licensing programs for commercial and private applicators. Through a focus group analysis, we identified a strong desire among consumers of aquatic plant management programs to better understand how these treatments worked. In response, we developed Aquatic Invasive Species (AIS) Management 101, a fully online course aimed at giving lake management clients and other engaged members of the public a better understanding of how AIS are managed and factors involved in meeting (or not) management goals. Topics covered include: biology of invasive species, the regulatory climate around management, different types of chemical and non-chemical management, pesticide education, and how treatments are evaluated. In this presentation, we will discuss what our 80+ participants learned in our inaugural offering of the course, what we learned as instructors, future directions for our program, and takeaways for other outreach and extension efforts that might employ a similar approach.

## **Novel Detections: eDNA & Other Strategies - Part 2**

### **Dispersal Dynamic and Recruitment of a Freshwater Invader using Otolith Chemistry**

*Olivier Morissette<sup>\*1</sup>, Frédéric Lecomte<sup>1</sup>, Nathalie Vachon<sup>1</sup>, Annick Drouin<sup>1</sup>, Pascal Sirois<sup>2 1</sup> Ministère des Forêts, de la Faune et des Parcs; <sup>2</sup> Université du Québec à Chicoutimi*

The quantification of trace elements incorporated into fish hard parts (e.g. scales, vertebrae or otoliths) represents an innovative technique in the study of their ecology. Notably, otolith chemistry has been used to describe the structure of fish stocks, migratory behaviour and the conservation of species at risk. However, this technique has been seldom used in the field of invasion biology, where it could represent a promising tool for rapid assessment of new invader and their dispersal dynamics. In this study, we used otolith chemistry to analyze the recruitment and movement of a well-known and expanding invader of the Richelieu and St. Lawrence Rivers, the Eurasian tench (*Tinca tinca*). Analyses were conducted on specimens captured in all the Quebec actual invaded range (from Lake Champlain to Lake Saint-Louis). Reconstructed movement by Random Forests analyses on the variations in the otolith chemical composition (Sr:Ca, Ba:Ca, Mg:Ca and Mn:Ca) showed that, contrary to assumed capacity, tench are exhibiting significant extensive migration within the invaded range. Movement extend is marked by two types of displacements (short and long distance), suggesting a stratified diffusion. This strategy could have contributed to accelerate the species secondary dispersal. This study shows the potential of using otolith chemistry to address multiple issues related to the management of aquatic invasive species.

### **Spatial Comparison of eDNA vs. Physical Fish Data from a Complex Freshwater Estuary**

*Anett Trebitz\*, Chelsea Hatzenbuehler, Joel Hoffman. Jon Barge, Greg Peterson, Erik Pilgrim, U.S. Environmental Protection Agency Office of Research and Development*

Analysis of environmental DNA (eDNA) offers a means of detecting target species and characterizing biological communities without having to collect the organisms themselves. The potential for eDNA to disperse widely from the organisms that generated it is a major reason for its appeal as a sampling target, but also raises important questions concerning what can be expected of spatial patterns arising from eDNA data relative to physical catch data. We explore these questions for fish communities in the St. Louis River Estuary - a hydrologically open and spatially complex freshwater estuary of Lake Superior - via the comparison of eDNA to physical survey data (~ 240 samples each) for 41 shared fish species. Comparisons among 6 broad spatial zones showed eDNA generally outperforming physical surveys in the early but not the late season, with details including a spatial gradient across zones and differences among the fish guilds involved. Four non-indigenous species were better detected with eDNA surveys, but two others were better detected with physical surveys. NMDS ordinations showed more spatial differentiation in fish structure in the late than early season for both survey types, but with relationships to fetch and vegetation more pronounced for physical surveys. GIS-based hot-spot analyses showed much more pronounced spatial clumping of many fish species with physical surveys than with eDNA data. eDNA surveys provides a sensitive tool for establishing species presence at the system scale but tends to obscure spatial distribution information that is relevant to location-specific restoration and management actions.

## **Tracking the Invasion Front of Round Goby using eDNA and Traditional Methods**

Scott George<sup>\*1</sup>, Barry Baldigo<sup>1</sup>, Christopher Rees<sup>2</sup>, Meredith Bartron<sup>2</sup>; <sup>1</sup> U.S. Geological Survey; <sup>2</sup> U.S. Fish and Wildlife Service

The Round Goby (*Neogobius melanostomus*) is an invasive benthic fish indigenous to the Ponto-Caspian region of Eurasia which recently colonized all five Great Lakes. Their populations are expanding eastward through the New York State Canal System towards the ecologically and economically important Hudson River and Lake Champlain watersheds. During 2016-2019, the U.S. Geological Survey, New York State Department of Environmental Conservation, and the U.S. Fish and Wildlife Service conducted a collaborative study to (a) document the distribution, relative abundance, and rate of expansion of Round Goby through the New York State Canal System and (b) compare the efficacy of environmental DNA (eDNA) and traditional fish sampling methods for monitoring the invasion front of this species. The presence of Round Goby was assessed using water samples (eDNA) and standard benthic trawls, bag seines, and minnow traps twice annually at 12 sites between Oneida Lake and Albany, NY during June and August in 2016-2019. Benthic trawling was the most effective traditional sampling method. Round Goby were captured at the 3 western-most sites and have invaded waters at least as far east as Utica, NY. Environmental DNA produced consistent detections at these locations and also suggests recent expansion 10-20 km downstream from Utica. However, eDNA results from some survey periods were challenging to interpret and suggest that this method is best paired with some level of effort using traditional sampling methods. Overall, expansion towards the Hudson River is occurring more slowly than expected given the rates of colonization observed elsewhere.

## **eDNA for Early Detection of AIS: Where are We and Where are We Going?**

Justin Townsend, Ramsey County Parks

Is environmental DNA or eDNA a tool that can be used by local managers for early detection of aquatic invasive species (AIS)? The answer is maybe. This talk aims to demystify that vague answer by diving into the practical applications of eDNA for those managing lake health. You do not need to be a geneticist for this talk. Rather the focus will be on partnerships that have been made to learn more, who the experts are that can help you navigate this complicated and rapidly evolving technology, what information eDNA will tell you, and finally what to do with those data. We will discuss efforts in Ramsey County Minnesota and others in the state to develop this as a practical tool with partners from lake associations to laboratories. This presentation will also give you the information to utilize this in your jurisdiction including laboratories completing these tests, potential studies to collaborate with, and what positive and negative tests mean. Looking to the future, a plan will be laid out at the end of this talk to scale this as a practical tool anyone can use.

## **Improved Eurasian Watermilfoil Management**

### **Advancements in Eurasian Watermilfoil Research and Management in Wisconsin**

Michelle Nault, Wisconsin Department of Natural Resources

In order to better understand the impacts of Eurasian watermilfoil (*Myriophyllum spicatum*) on Wisconsin lakes, Department of Natural Resources staff have worked in close collaboration with numerous stakeholders to compile over 15 years' worth of quantitative data collected on hundreds of waterbodies across the state. This data is being used to help develop and implement plans for strategic and efficient monitoring and management of this non-native aquatic plant. Specifically this presentation will discuss the current statewide distribution, abundance, and genetics of watermilfoil in Wisconsin, the results of a long-term watermilfoil monitoring project,

as well as a discussion on the efficacy and selectivity of several currently utilized management techniques. The results may surprise you, and challenge some commonly held beliefs about the ecology and management of this aquatic invasive species.

### **Assessment of Two Large-Scale ProcellaCOR EC Treatments in Northern Indiana**

*Reid Morehouse<sup>\*1</sup>, Willey Leif<sup>2</sup>, Mark Heilman<sup>1</sup>; <sup>1</sup> SePRO; <sup>2</sup> Aquatic Control*

In late spring 2020, ProcellaCOR® EC (a.i., florypyrauxifen-benzyl) was applied to large fractions of two lakes (95 acres - 57% treated, 23 acres - 100% treated) located in northern Indiana. Each lake treatment used a rate of 2 PDU (Prescription Dose Units) per acre-foot (3.86 µg ai/L). Prior to treatment, both lakes were heavily infested with the invasive Eurasian watermilfoil with frequency of occurrences (FOO) as high as 96%. Water quality samples for key nutrients (total phosphorus and free reactive phosphorus) were collected pre-and post-treatment along with herbicide dissipation monitoring for one lake at 3 hours, 24 hours, 3 days, and 7 days post application (10 sites). ProcellaCOR decreased below 1 ppb in 80% of the sites at 3 days and 100% of the sites at 7 days. One month after treatment the FOO of viable Eurasian watermilfoil was 0%, while the FOO for native plants increased in both lakes, further indicating the selectivity towards invasive milfoils. Early analyses indicate great control of Eurasian watermilfoil while allowing native plants to grow without competition. These two lakes will be monitored using quantitative point-intercept vegetation surveys 1 and 2 years out to evaluate the longer-term efficacy of these two large-scale ProcellaCOR EC treatments.

### **In-lake Evaluation of Florypyrauxifen-benzyl (ProcellaCOR) on Invasive Hybrid Watermilfoil in a Central Minnesota Lake**

*Keegan Lund\*, Kylie Cattoor\*, April Londo, Minnesota Department of Natural Resources*

Eurasian watermilfoil (*Myriophyllum spicatum*) and hybrid watermilfoil (*Myriophyllum spicatum* x *M. sibiricum*) are invasive submersed aquatic macrophytes that cause recreational and ecological disturbance in many North American waterways. In Minnesota, these problematic invasive species are primarily managed to maintain open water for recreational purposes and also to prevent the spread and expansion in and among lakes. The primary management tools utilized are selective herbicidal treatments or mechanical cutting of the invasive plants. In spring 2018, a new selective auxin mimic herbicide was trialed for the first time in a Minnesota waterbody (Lake Jane, near St. Paul, Minnesota) targeting hybrid watermilfoil. A 4.9 hectare (12 acre) area was treated with the herbicide florypyrauxifen-benzyl in June 2018. Aquatic vegetation surveys were conducted pre and post-treatment to assess the efficacy of the herbicide treatment in an area of dense hybrid watermilfoil growth. Changes in aquatic plant species presence and rake abundance were measured and showed no significant declines. Whereas, hybrid watermilfoil decreased 71% following the spot-treatment herbicide application. Hybrid watermilfoil was controlled using this treatment method and appears to be an effective auxin mimic herbicide for invasive watermilfoils.

### **Integrating Genetics and Herbicide Studies to Improve Watermilfoil Management Outcomes**

*Ryan Thum<sup>\*1</sup>, Gregory Chorak<sup>1</sup>, Raymond Newman<sup>2</sup>, Jo Latimore<sup>3</sup>, Erick Elgin<sup>3</sup>; <sup>1</sup> Montana State University; <sup>2</sup> University of Minnesota; <sup>3</sup> Michigan State University*

Aquatic plant stakeholders in the Upper Midwest increasingly recognize that Eurasian watermilfoil (including hybrids) is genetically diverse, and that strains can differ in their growth, spread, impacts, and herbicide response. One promising approach for Eurasian watermilfoil management is developing methods that use genetic information to predict how a specific watermilfoil population will respond to a proposed control tactic (e.g., a specific herbicide) before implementing management. Here, we illustrate how we are combining genetic

survey and monitoring of invasive watermilfoil populations with herbicide studies to inform management. One significant finding is that a given strain can be found in more than one lake. Identifying lakes that share strains can facilitate communication among stakeholders regarding management experiences with particular strains. Further, by prioritizing strains to target for herbicide studies, quantitative lab and field studies of herbicide response can inform management on multiple lakes containing a given strain. For example, we found one hybrid strain in eight lakes across Michigan, and a laboratory fluridone assay identified this strain as resistant to 6ppb fluridone. Therefore, lakes with a high proportion of this strain should not be targeted for control with 6ppb fluridone. In contrast, our fluridone assay identified several strains of watermilfoil that appear susceptible to 6ppb fluridone, and therefore lakes dominated by these strains would likely respond well to fluridone treatment. We will provide updated information on genetic surveys and herbicide studies, and propose next steps for integrating genetic information into management planning and evaluation.

## **Protecting Mighty Oaks: Advances in Oak Wilt Detection**

### **Spectral Reflectance Detects Oak Wilt Decline in Oaks at the Landscape Scale**

Gerard Sapes<sup>\*1</sup>, Cathleen Lapadat<sup>1</sup>, Jennifer Juzwik<sup>2</sup>, Rebecca Montgomery<sup>1</sup>, Nanfeng Liu<sup>3</sup>, Phillip Townsend<sup>3</sup>;  
<sup>1</sup> University of Minnesota; <sup>2</sup> USDA Forest Service; <sup>3</sup> University of Wisconsin - Madison

The oak wilt disease caused by the invasive fungal pathogen *Bretziella fagacearum* is considered the most lethal threat to oaks (*Quercus* spp.) in the Midwest. As such, there is increasing interest in early detection and monitoring of its spread. Canopy spectral reflectance contains information describing both species identity and physiological status that can be used to identify diseased oaks. We have developed partial least square discriminant analysis (PLSDA) models using airborne spectroscopy to detect canopies infected by oak wilt before visual symptoms appear. We achieve high accuracy through a stepwise process in which we first distinguish oaks from other species (90% accuracy), then red oaks from white oaks (93% accuracy), and finally infected trees (80% accuracy). Our results indicate that including short-wave infrared wavelengths and using late summer data provide models that may be more generalizable across sites or years. Additionally, we identified several multispectral indexes associated with physiological status that detect statistically significant differences between healthy and infected trees. Overall, indexes were most significant during late summer, especially those associated with canopy photosynthetic function and water status. Together, models and indexes indicate that detection accuracy increases when late summer data is used because differences in physiological decline between infected and healthy trees are more marked. Our study suggests that managers can use hyperspectral models at the landscape scale and multispectral indexes at the stand level to detect oak wilt before visual symptoms appear and before the disease has had the chance to spread to surrounding healthy trees.

### **Seasonal and Regional Distributions, Degree-Day Models, and Phoresy Rates of the Major Sap Beetle (Coleoptera: Nitidulidae), Vectors of the Oak Wilt Fungus, *Bretziella fagacearum*, in Wisconsin**

Stephanie Jentz<sup>\*1</sup>, Jennifer Juzwik<sup>2</sup>, Patrick Tobin<sup>3</sup>, Kenneth Raffa<sup>4</sup>; <sup>1</sup> Wisconsin Department of Agriculture and Consumer Protection; <sup>2</sup> USDA Forest Service; <sup>3</sup> University of Washington ; <sup>4</sup> University of Wisconsin - Madison (emeritus)

Oak wilt is a lethal disease caused by the invasive fungus *Bretziella fagacearum*, which is transmitted belowground via root grafts and aboveground by sap beetles (Nitidulidae). Attempts to limit spread and impact of *B. fagacearum* emphasize limiting harvesting and pruning to periods of vector inactivity. However, there is limited information on sap beetle activity periods, responses to temperature, and phoresy frequencies of fungi. We sampled two major vectors in Wisconsin, *Colopterus truncatus* and *Carpophilus sayi*, for 2 years to quantify their seasonal and geographic abundances. Trapping was performed in 12 oak stands, and beetles were assayed

for *B. fagacearum*. *C. truncatus* was captured from March until November, peaking during April and May. *C. sayi* was captured from April until November, peaking in May and July. Relative abundances (N = 15,980) were 59.3% *C. truncatus* and 40.7% *C. sayi*. *Carpophilus sayi* was more abundant in southern Wisconsin, whereas *C. truncatus* was more evenly distributed. Both species were present at asymptomatic sites. All sites with oak wilt centers yielded beetles with viable fungal propagules, with the frequency of association ranging from 1 to 50%. Sites asymptomatic for oak wilt contained both beetle species, but no vector-borne viable pathogen. Degree-day models were constructed to improve the generality of these results and estimate cumulative emergences across a latitudinal range over the previous 10-yr means and extremes. Because activity by *C. truncatus* and *C. sayi* spans the seasonal activities of oak wilt vectors, these results can help guide oak management practices.

### **Novel Rapid Detection Technology for Oak Wilt Disease**

Vinni Thekkudan Novi<sup>\*1</sup>, Melanie Moore<sup>2</sup>, Quichen Dong<sup>1</sup>, Jennifer Juzwik<sup>2</sup>, Abdenmour Abbas<sup>1</sup>; <sup>1</sup> University of Minnesota; <sup>2</sup> USDA Forest Service

Oak trees (*Quercus* spp.) play a significant role in the ecosystem and are considered economically important for several reasons. They usually grow in the Northern hemisphere and are common in the upper Midwest regions of North America. Oak trees are prone to oak wilt disease, caused by the fungus, *Bretziella fagacearum*, which is of huge concern due to the reduced profitability in their production. This disease is characterized by the growth of the fungus on the outer sapwood of infected trees, which restricts flow of water and nutrients to the tree and leads to foliage wilting. The affected tree cannot be cured and so, early, and rapid identification of the infection is necessary to prevent spreading. This study aims to optimize and validate a previously developed rapid detection technique for target pathogen identification. Tests will be conducted on real samples of infected red oak trees and potentially extend to testing bur and white oak species. The detection system is based on the aggregation of gold nanoparticles (AuNPs), designed to specifically detect pathogen DNA strand in the sample. This catalyzes the generation of a high intensity chemiluminescence signal when the reactants, luminol and hydrogen peroxide, are introduced. In the absence of the target strand, the AuNPs do not aggregate and a weak signal is obtained. Preliminary studies on red oak samples have shown the sensitivity of the system to be 96%. This shows promise for the application of this rapid technique in the early detection of infected oak trees.

### **Oak Wilt Outreach in Ontario: A Model for Educating Communities on Invasive Species**

Mackenzie DiGasparro, Invasive Species Centre

The Invasive Species Centre is a Canadian not-for-profit organization focused on protecting Canada's lands and waters from invasive species through the connection of stakeholders, knowledge, and technology. The Centre's Forest Invasives program focusses on protecting the health of Canada's forests from invading species. This program prioritizes educating the public as well as forestry professionals through the organization of workshops and public information sessions. One of the program's main priorities in terms of forest health is oak wilt, a vascular disease of oak trees caused by a fungal pathogen. The Centre has seen great success in terms of oak wilt outreach initiatives in the past several years. In the last fiscal year, the Centre has reached an audience upwards of 250 individuals through in person oak wilt events alone. The model that the Centre follows for delivery of its outreach and training sessions essentially follows a 4-step process: engage partners, public outreach, knowledge transfer, and community action. Following this process allows each workshop to meet the needs of local partners, address gaps in knowledge from common public inquiries, transfer that knowledge to appropriate members of the community, and finally have those community members pass on their knowledge to others in their circles. This training model can be adapted for any invasive species public training and can be used as one of several tools to both engage and educate a public audience on invasive species threats in a community.



## **Translating Science into Practice for Climate-Smart Invasive Species Management**

### **Translational Invasion Ecology: Bridging Research and Practice to Address One of the Greatest Drivers of Global Change**

*Toni Lyn Morelli\*<sup>1</sup>, Carrie Brown-Lima<sup>2</sup>, Jenica Allen<sup>3</sup>, Audrey Barker Plotkin<sup>4</sup>, Evelyn Beaury<sup>4</sup>, Emily Fusco<sup>4</sup>, Bridget Griffin<sup>4</sup>, Brittany Laginhas<sup>4</sup>, Lara Munro<sup>4</sup>, Bethany Bradley<sup>4</sup>; <sup>1</sup>U.S. Geological Survey; <sup>2</sup>New York Invasive Species Research Institute; <sup>3</sup>Mount Holyoke College; <sup>4</sup>University of Massachusetts - Amherst*

The disconnect between research and practice is an issue in many fields of inquiry, but is particularly critical with invasive species where effective management decisions are highly dependent on information generated by research. We propose Translational Invasion Ecology to increase outcomes and improve results as climate change and globalization exacerbate this global threat. Expanding on Translational Ecology, a new term for an old idea that resource managers and scientists need to work together to solve pressing ecological problems, TIE is an intentional process in which researchers, stakeholders, and decision makers work collaboratively to develop research on invasive species via joint consideration of the sociological, ecological, and political contexts of invasives management that ideally results in improved decision making. We will delineate the steps of TIE and show examples of how it is being successfully carried out across the globe, including by the Regional Invasive Species and Climate Change (RISCC) network. RISCC addresses the question that was asked by invasive species managers “How can we manage for upcoming biological invasions in the light of climate change?” by identifying stakeholder needs, synthesizing existing research, developing new research and tools, and supporting increased collaboration among scientists and managers. Invasive species management is in need of new strategies, both for research and application, and the TIE framework provides a new path for success.

### **Biological Control Programs as a Model of Translational Invasion Research**

*Carrie Brown-Lima, New York Invasive Species Research Institute*

Biological control programs, programs that seek to control invasive species using natural enemies from the target species native range, are long-term research endeavors that take place in multiple countries, in quarantine facilities and field trials. Researchers are required to go through many steps starting with the identification of potential biocontrol agents and eventually assuring that the selected species will not feed on any native species. When these phases are complete and agents are approved for release in the introduced range, research continues in the form of field trials, which often require coordination among the research community and the management agencies that utilize the biological control agents. Although not commonly discussed in the context of translational research, the development and implementation of biocontrol programs offers an interesting example of how manager identified needs regarding invasive species can motivate funding, collaboration and research directions, and how bridging individuals or organizations, such as extension programs, can facilitate and promote this relationship and improve the outcomes. Researcher- manager collaborations are essential to implement long term monitoring strategies and to assess effectiveness of biocontrol over time, especially given climate change and other land transformation contexts. This talk will provide examples of such collaborations and the factors that led to successful partnerships.

### **Resilient and Connected: Our Vision for Protecting Biodiversity**

*Shaun Howard, The Nature Conservancy*

Climate change is changing habitat suitability, altering the home ranges for plant and animal species worldwide, and by extension allowing spread of invasive species into new areas. Despite this, many sites and landscapes already show higher than average resilience to climate change impacts, and therefore are natural priorities for future conservation efforts, including invasives management. Using The Nature Conservancy's Resilient Land

Mapping Tool, Shaun will describe where our most resilient and connected lands in the Great Lakes lie, how collaborative, strategic protection can be used to provide optimal native species habitat in a changing world, and the complementary and sometimes conflicting relationship between protecting climate resilient lands and preventing invasive species proliferation and associated impacts.

### **Stakeholder-Driven Tools for Visualizing and Listing Climate-Driven Range Shifts in Terrestrial Invasive Plants**

*Jenica Allen<sup>\*1</sup>, Jeff Garnas<sup>2</sup>, Chuck Barger<sup>3</sup>, Joseph LaForest<sup>3</sup>, Bethany Bradley<sup>4,1</sup> Mount Holyoke College; <sup>2</sup> University of New Hampshire; <sup>3</sup> University of Georgia; <sup>4</sup> University of Massachusetts - Amherst*

Invasive plants regularly shift their geographic ranges as climate continues to change. Many species will disperse to new regions naturally or accidentally, necessitating preventative policy and early detection and rapid response (EDRR) programs. Following a translational invasion ecology model, we connected biogeographical invasive plant and climate change research to stakeholder need to identify which species to look for and where. We forecast mid-century (2050) climate-driven range shifts of nearly 900 terrestrial invasive plants in the continental U.S. based on observations in the Early Detection and Distribution Mapping System (EDDMapS) database and others. The resulting maps allow stakeholders to identify new potential invasive plants to their state before they arrive on the local landscape. We will demonstrate two web-based, interactive tools available for mapping and identifying these range-shifting invasive plants. The first tool maps expected county-level range dynamics between now and 2050 for user-selected species, estimating probable range expansion, contraction, or stability. The second tool generates lists of invasive plants that have climate-driven range expansion potential into a user-defined state and refines that list based on user-controlled geographic proximity of current observations. These dynamic visualizations of geographic range and watch lists can be incorporated into stakeholder planning and prioritization for early detection and rapid response programs and proactive policies aimed at the prevention of invasive spread into new areas. We highlight the potential of the tool to contribute to invasive plant management via proactive regulation using New York State as an example.

### **Building a Regional Collaboration of Northeast State Invasive Species Councils to Proactively Address Range-Shifting Invasive Plants**

*Bethany Bradley<sup>\*1</sup>, Carrie Brown-Lima<sup>2</sup>, Toni Lyn Morelli<sup>3</sup>, Jenica Allen<sup>4</sup>, Evelyn Beaury<sup>1</sup>, Emily Fusco<sup>4</sup>, Brittany Laginhas<sup>1,1</sup> University of Massachusetts - Amherst; <sup>2</sup> New York Invasive Species Research Institute; <sup>3</sup> U.S. Geological Survey; <sup>4</sup> Mount Holyoke College*

Invasive species that are shifting their ranges due to climate change are a prominent management concern. The Northeast U.S. is projected to be a hotspot of future plant invasion, and proactively addressing these new invaders before they establish will require coordinated regional action between states. But our analysis of regulated plant lists shows that, on average, state regulatory lists only have an overlap of 32% with neighboring states and every state uses a different process to establish their regulatory list. In addition, more than 75% of regulated species are already widespread within the state and therefore existing regulations are unlikely to reduce invasive plant populations. In order to address this issue, the Northeast Regional Invasive Species & Climate Change (RISCC) Management network initiated a working group of state invasive plant council representatives in order to strengthen alliances at the regional level, facilitate information exchange, and discuss ways to develop proactive regional policy and management. This presentation will describe the ongoing development of this working group as an example of translational invasion ecology.

## TUESDAY MORNING PLENARY

### Actions Taken and Lessons Learned Along the Journey: Six Decades of Sea Lamprey Control

Dale P. Burkett, Sea Lamprey Control Director, Great Lakes Fishery Commission

The sea lamprey, *Petromyzon marinus*, an incredibly destructive invasive species, entered Lake Ontario in the mid-1800s, and the upper Great Lakes beginning in 1921 where they inflicted significant economic damage, harmed the fishery and ecosystem, and changed the way of life in the region. Of the more than 180 non-native species in the Great Lakes basin, sea lampreys are the only invader controlled basin-wide and the only example in the world of a successful aquatic vertebrate pest control program at an ecosystem scale. The Great Lakes Fishery Commission, pursuant to the Convention on Great Lakes Fisheries, delivers sea lamprey control in partnership with the U.S. Fish and Wildlife Service, Fisheries and Oceans Canada, and the U.S. Army Corps of Engineers. The U.S. Geological Survey conducts critical sea lamprey research to aid in control. This control program has reduced sea lamprey populations by 90% during the past six decades. Successes, setbacks, development of control tools, shifts in social license, shifting baseline syndrome, prognostications about the future, and the challenges of controlling sea lamprey in a multi-jurisdictional environment are explored.

## TUESDAY MORNING CONCURRENT SESSIONS

### Modeling to Understand Ecology & Invasive Species Spread

#### Developing Phenological Models to Improve Management of Pesky Plants

Rebecca Montgomery\*, Abigail Anderson, Byju Govindan, Stephan Carlson; University of Minnesota

The management and control of invasive species depends strongly on applying effective management strategies timed to appropriate life cycle stages. For example, mowing after seed maturation potentially contributes to spread whereas mowing during early flowering phases can prevent seed development and maturation. Thus, timing of management is critical to success. Effective timing requires predicting when key developmental stages will be reached. We partnered with Nature's Notebook, a program of the USA-National Phenology Network to develop a national community science campaign, Pesky Plant Trackers, to collect phenology data on wild parsnip (*Pastinaca sativa*) and Japanese knotweed (*Polygonum cuspidatum*). We present our approach to online training and engagement, key data outcomes, and an overview of models that are currently in development to provide temperature-based predictions of timing of key life cycle stages based on community science data.

#### Assessing Eastern U.S. Forest Susceptibility to Four Invasive Insect Pests in the Context of Landscape Connectivity

Jason Reinhardt\* and Matthew Russell; University of Minnesota

Insect pests are a widespread and growing threat to U.S. forests. In this study, we seek to evaluate the susceptibility of forests across the eastern U.S. to attack and infestation by four major invasive insects. The insects of interest include two native (mountain pine beetle [*Dendroctonus ponderosae*] and southern pine beetle [*D. frontalis*]), and two non-native beetles (oak splendor beetle [*Agrilus biguttatus*] and brown spruce longhorn beetle [*Tetropium fuscum*]). All four species have the potential to cause significant ecological and economic damage if they become established (or expand further into) in eastern forests. We define and articulate the susceptibility of eastern U.S. forests to these invasive beetles using a series of analytical approaches. Beetle habitat suitability is identified using a standard random forest based distribution modeling

approach, leveraging data from online invasive species databases and aerial surveys, in addition to a suite of environmental datasets. Forest susceptibility is computed using a multi-step implementation of spatial multi-criteria decision analysis, considering datasets including beetle habitat suitability, host tree basal area, and invasibility factors. The forest susceptibility estimates produced here are placed into context using a landscape connectivity analysis. Landscape connectivity is computed using a circuit-theory based approach, allowing for the assessment of broad-scale connectivity among areas of susceptible forest. We find variation in the area and distribution of susceptible forest for each of the four invasive beetles, with particularly high susceptibility across multiple species for segments of the Appalachian range and the northeastern U.S. Connectivity results indicate additional areas of potential concern.

### **Making Better MaxEnt Models for Invasive Species**

*Amy Morey\*; University of Minnesota, Rob Venette; USDA Forest Service and University of Minnesota*

Forecasting the potential distribution of invasive species is vital to proactive management and policy decision-making. Correlative models, which statistically relate species occurrence with a set of environmental variables, are commonly used to estimate how suitable new areas might be for an invasive species to survive. These tools are appealing to risk managers in part because they require relatively little detailed biological data. However, the "transferability," or appropriateness of these estimates for areas outside of the space used to develop the model (i.e., potential invaded range vs. the native range), is questionable and not well studied. Using the popular correlative modelling platform, MaxEnt, we tested how multiple factors affected transferability of forecasts for the European gypsy moth (*Lymantria dispar dispar*), an insect brought to the U.S. in the 1860s from Europe and subsequently well-monitored in spread. In particular, our models were tested on how well they predicted the last 30 years of gypsy moth spread in North America. A major finding from our study was that models built and assessed using typical methodology for invasive species (e.g., using records from the full native geographic range) performed the worst (i.e., were the least transferable). Conversely, models based on the purported genetic source of the eastern North American gypsy moth population (i.e., a subset of the native range) showed the greatest transferability. Our method of modelling with MaxEnt is intended to highlight important areas of consideration for pest risk managers and researchers using such tools for forecasting invasive species.

### **Improving Predictions of Range Expansion for Invasive Species using Joint Species Distribution Models and Surrogate Co-occurring Species**

*Ryan Briscoe Runquist\*, Thomas Lake, David Moeller; University of Minnesota*

Species distribution models (SDMs) are often used to forecast potential distributions of important invasive or rare species. However, situations where models could be the most valuable ecologically or economically, such as for predicting invasion risk, often pose the greatest challenges to SDM building. These challenges include non-equilibrium range expansion, low or uneven prevalence, and interest in projecting distributions into environments that are non-analogous to the environments used for model building. In our study, we took a novel approach to build robust surrogate species distribution models of invasive species that leveraged the occurrence-environment correlations between invasive species and co-occurring native community members. The correlations were obtained from a joint species distribution model (JSDM) of a densely-sampled database of 10,336 MN plant communities from across the state of Minnesota, USA. Surrogate models performed substantially better than traditional SDMs in predicting occurrences along the northern invasion margin. Surrogate models also predicted greater range expansion beyond the current geographic range. The increased performance was likely due to the increased amount of analogous environmental space included during model building and in projections of habitat suitability. These results demonstrate that modelers can take advantage of detailed community data to build effective predictions of invasive species along expanding range margins.

## **Terrestrial Eutrophication and Afforestation as Major Driver of Invasion**

*Stephen Thomforde; Stantec Consulting Environmental Services*

Declines in Midwest woodland integrity are often blamed on invasive species; however, this presentation suggests many degraded Midwest woodlands are the result of a positive feedback process, termed here as Terrestrial Eutrophication and Afforestation (TEA), and invasive species are symptomatic thereof. The presentation models the TEA process, from open grassland-savanna to the occluded, invasive species dominated, eutrophic afforested woods. The model illuminates how the loss of keystone processes, biomass harvest by herbivores and fire, increases system nitrogen that favors faster-taller growing plants that create more shade, which in turn selects for faster taller growing vegetation that increase detrital loads and decompose more nitrogen back into the system. The climax result is a novel dysfunctional TEA state, dominated by both native and non-native woody, nitrophilic, non-edible and labile species that eventually eliminates the historic, highly evolved, functional biotic assemblage. That catastrophic state is reinforced via system nutrient dynamics and by forest-centric social myths. Knowledge provided by modeling TEA allows us to design state transition strategies to shift the eutrophic condition back towards the oligotrophic state via restoration of keystone processes that impose control over nutrient cycling. In summary, the presentation exposes the role of keystone processes in maintenance of ecosystem integrity, nitrogen's impact on plant communities, nitrophilic vegetation impacts on eutrophication, thresholds and positive feedbacks that facilitate and reinforce TEA, concepts of invasive species as symptomatic of TEA, the power of narratives over scientific validity, and restoration strategies based on state transitions models.

## **Sustaining Community & Citizen Science through Volunteer Training**

### **Invasive Species and Community Action**

*Lauren Bell; Invasive Species Centre*

Early detection to new and emerging invasive species is essential in effective management. The Early Detection and Rapid Response Network (EDRR) Ontario utilizes a proven community engagement model to move into new priority areas and utilize education and outreach to facilitate on the ground community action. Through our presentation we will overview the model utilized by the EDRR Network, and discuss key steps, successes and challenges in mobilizing effective community action to prevent the spread of invasive species in Canada.

### **Managing Invasive Species with the Help of Citizen Scientists and Experienced Mentors**

*Christopher Gaetzke; Lower Chippewa Invasives Partnership, Inc.*

Lower Chippewa Invasives Partnership's Invasive Monitoring Program (IMP) is a culmination of many successful, citizen-based, and professional monitoring protocols and programs that focuses on identifying emerging invasive plants and native plants through citizen scientists. The mapped plant locations are made public knowledgebase through the EDDMapS Midwest website. The locations of mapped invasive plants are being discussed at the local town and county government board meetings, in order to formulate plans for best management practices such as change of mowing practices, targeted herbicide treatments, increased awareness of invasive plants with a goal of more manageable maintenance of public roadsides as well as private and public properties. IMP aims at increasing invasive species control and decreased mowing operations in five townships and two counties in West Central Wisconsin. IMP promotes citizen involvement in government and non-profit organizations in a new way that will build each community's capacity to prepare for climate change and future challenges. IMP brings community stakeholders together to make informed land management decisions from the results of the surveys at public meetings like never before.

### **EmpowerU: Energizing Citizens with the Skills to Affect Change in their Communities**

*Gail Epping Overholt\*<sup>1</sup>, Anne Pearce\*<sup>2</sup>; <sup>1</sup> University of Wisconsin Arboretum, <sup>2</sup> University of Wisconsin - Madison*

Training for natural resource volunteers often focuses on technical content. How do we also give volunteers the "soft" skills and confidence to use their natural resource knowledge to actually affect change in their communities? The EmpowerU curriculum, developed by University of Minnesota Extension, trains volunteers in the skills they need to influence decision-makers about invasive species issues. Using a flipped classroom curriculum, we trained volunteers, CISMA coordinators, and other natural resources professionals in topics such as listening skills, questioning skills, and framing of issues. The curriculum guides participants through the step-by-step creation of individualized plans to engage with decision-makers in their communities on an issue of their choice. With small adjustments, the curriculum can be applicable to any other natural resource issue of interest. In this session, we will describe how we implemented EmpowerU in Wisconsin during the pilot phase of the curriculum and share preliminary outcomes we have observed. As the curriculum is now available for all, we will also highlight key aspects of the curriculum and offer ideas for adapting it for different audiences.

### **Online Volunteer Program: Increasing Accessibility, Flexibility, and Engagement in Rural Communities**

*Lindsay Peterson; Wild Rivers Invasive Species Coalition (WRISC)*

Volunteer engagement is a challenge most invasive species groups are faced with. This challenge can be especially prominent in rural communities with dispersed populations, as it can be difficult to get volunteers to travel long distances for an event or to alternatively host many small events throughout these communities. Other challenges take the form of tracking volunteer time accurately or encouraging confidence in volunteers to perform tasks on their own. Recognizing these challenges, the Wild Rivers Invasive Species Coalition (WRISC) sought to establish a more formalized volunteer program with increased accessibility across a five county, two state management area. Combining multiple online resources, including an online volunteer registration and scheduling site, Google Maps, and WRISC's own website, WRISC has developed an accessible and modern volunteer interface. Volunteers are able to sign up for days and times that work best for them, select sites from the interactive map, find all training resources needed to conduct various monitoring activities, and track their time spent. As virtual interactions continue to be a primary form of engagement for the unforeseen future, this program allows WRISC to continue accomplishing goals while maintaining vital volunteer connections and growing these relationships across the rural communities within the management area.

### **Successfully Inheriting an Invasive Species Outreach Program**

*Rachel Carroll\*, Rebekah Wallace, Chuck Barger; University of Georgia*

Natural resource personnel often inherit existing outreach programs. A successful exchange of management is required for maintaining the continuity and functionality of a program. Here, we use an ongoing project, The First Detector Network in Georgia, to demonstrate ways to achieve a smooth transition using a checklist to provide guidance. The First Detector Network is a cooperative agreement between state and federal agencies to establish a dedicated network of well-trained volunteers that assist in the ongoing collection of invasive species detections in the state. By utilizing the checklist, project managers stay organized during a transition, assess the current and future status of the program, and pinpoint areas of improvement.

## **Tackling Dreissenid Mussels and New Zealand Mudsnails**

### **Lake Michigan Quagga Mussel (*Dreissena rostriformis bugensis*) Control Demonstration Project**

Erika Jensen<sup>\*1</sup>, Doug Bradley<sup>2</sup>, Harvey Bootsma<sup>3</sup>, Vincent Denef<sup>4</sup>, Kathryn Schmidt<sup>4</sup>, Brenda Moraska Lafrancois<sup>5</sup>; <sup>1</sup> Great Lakes Commission; <sup>2</sup> LimnoTech; <sup>3</sup> University of Wisconsin - Milwaukee; <sup>4</sup> University of Michigan; <sup>5</sup> National Park Service

In 2019, the Invasive Mussel Collaborative coordinated a partnership-based, collaborative control project for invasive mussels on a Great Lakes coastal reef using the selective toxicant Zequanox injected under a benthic barrier. The goal of the project was to better understand the effectiveness and feasibility of the approach, and to identify potential changes in the physical habitat and the biological community associated with the targeted treatment areas. This project expands existing National Park Service, Michigan Department of Natural Resources and University of Wisconsin-Milwaukee efforts to remove invasive mussels and reduce harmful impacts to the local ecosystem in the Sleeping Bear Dunes National Lakeshore and Good Harbor Reef areas of Lake Michigan. Preliminary results show dreissenid mussel mortality rates to be as high as 97% post-treatment. The project aligns and addresses objectives in the Invasive Mussel Collaborative Strategy to Advance Management of Invasive Zebra and Quagga Mussels which offers a roadmap to improve invasive mussel control in the Great Lakes region. Broadly, the collaborative seeks to advance scientifically sound technology for invasive mussel control to produce measurable ecological and economic benefits. It provides a forum for communication and coordination and is identifying and aligning science and management goals into a common agenda for invasive mussel control. A broad membership base of states, provinces, tribal and other entities and a well-organized communication network facilitates the exchange of information between scientists, managers, and stakeholders.

### **Eradicating Invasive Mollusks (*Dreissena* and NZMS) when Fish are Present**

David Hammond\*, EarthTec QZ, Gavin Ferris, Solitude Lake Management, Inc.

In Fall of 2017, a treatment protocol was implemented to eradicate invasive quagga mussels (*Dreissena rostriformis bugensis*) from an entire 30-acre lake in Pennsylvania using 3 applications of a liquid formulation of acid-stabilized ionic copper (EarthTec QZ) delivered over a period of 37 days. Mussel mortality was estimated using cages of adult mussels, suspended at different locations and depths throughout the lake and death of the last caged mussel was confirmed 40 days after the initiation of treatment. In the 3 years since treating, stakeholders have sampled and monitored for any sign that quagga mussels might still be present. The results of those eDNA tests and plankton tows that were painstakingly analyzed by an impartial, independent environmental consultant using microscopy will be presented, including both invasive and non-target species. A cumulative total of just 0.44 mg/L as copper was applied in the entire treatment. Campaigns to educate boaters and implement clean-drain-dry practices remain the best strategy against invasive mussels - prevention is the best cure - but for situations where preventative efforts have proven insufficient, this landmark experience provides a glimmer of hope. As a historic project illustrating for the first time the potential to eradicate invasive mussels from entire water bodies, this case study and its long-term outcome provide an important lesson to invasive species managers everywhere who seek practical and economical alternatives for control.

### **Field Studies on Low-dose Copper Treatments for Dreissenid Mussel Control**

Angelique Dahlberg<sup>\*1</sup>, Diane Waller<sup>2</sup>, James Luoma<sup>2</sup>, Nicholas Phelps<sup>1</sup>, Matthew Barbour<sup>2</sup>; <sup>1</sup> University of Minnesota; <sup>2</sup> U.S. Geological Survey

Zebra mussels (*Dreissena polymorpha*) are one of the most problematic invasive species in the Great Lakes region, causing significant ecological and economic impacts in waterbodies where established. Copper compounds used in rapid response and eradication efforts of zebra mussels have generally targeted the adult

life stage. We are evaluating the short- and long-term effects of low-dose copper (60-100 µg/L) as EarthTec QZ on zebra mussel settlement as well as non-target native species. In 2019, we treated St. Alban's Bay (66.3 hectares) in Lake Minnetonka with 100 µg Cu/L followed by four bump treatments every-other day at 60 µg Cu/L for a total of ten days to maintain the initial exposure dose. We conducted pre- and post-treatment monitoring in St. Alban's Bay (EarthTec QZ treated) and Robinson Bay (untreated control) of veliger and adult zebra mussel density, water quality (specific conductance, pH, dissolved oxygen), chlorophyll a levels, benthic invertebrate abundance and family richness, and zooplankton abundance and family richness. We assessed survival of caged native mussels (fatmucket), fathead minnows, bluegills, largemouth bass, yellow perch, and adult zebra mussels. Tissue copper concentrations we determined for all caged animals. We enumerated zebra mussel settlement at 30- and 90-d post-treatment. Preliminary results suggest that treatments effectively reduced zebra mussel veliger density, juvenile zebra mussel recruitment, and live zebra mussel density. Non-target impacts varied and will be presented. Follow up monitoring will occur in 2020 & 2021 in Lake Minnetonka.

### **The Great Lakes New Zealand Mud Snail Collaborative**

*Jeremy Geist; Trout Unlimited, Inc.*

The New Zealand mud-snail (NZMS) (*Potamopyrgus antipodarum*), a world-wide invader, is expanding its range throughout North America with recent invasions in rivers of the Laurentian Great Lakes region. Studies conducted in the western United States have documented impacts to benthic-invertebrate and fish communities, and ecosystem function. However, given the very recent discovery of NZMS in the rivers of the Great Lakes region, the potential impacts are currently unknown. Learn how a regional collaborative is seeking to improve knowledge on potential impacts, minimize spread, better inform management activities, and raise public awareness.

### **Conservation Dogs Locate AIS Infestations: A Collaborative Project Overview**

*Amy Wagnitz\* and Laura Holder; Midwest Conservation Dogs, Inc.*

Professional conservation detection dogs can identify the absence or presence of aquatic invasive species (AIS) with reliable accuracy. Their ability to detect an aquatic target diluted into the parts per trillion has enabled them to swiftly and efficiently lend a hand in aquatic conservation. The New Zealand mudsnail (*Potamopyrgus antipodarum*) is a miniscule AIS in the Midwest, with a number of known populations in Wisconsin. Unfortunately, because the New Zealand mudsnail is so small and can become established with only one individual, the extent of spread through Wisconsin rivers is a concern. Midwest Conservation Dogs, Inc. recently collaborated with the River Alliance of Wisconsin and the Wisconsin Department of Natural Resources to conduct New Zealand mudsnail surveys in the Black Earth Creek Watershed. This presentation will highlight the project and how conservation detection dogs are an innovative, emerging and non-invasive technology in various AIS detection.

## **Emerging Invasive Plants: Control & Prevention**

### **Japanese Stiltgrass (*Microstegium vimineum*) Management in Southern Indiana**

*Emily Finch; Dubois County Soil & Water Conservation District*

Japanese Stiltgrass (*Microstegium vimineum*) is an annual invasive grass originally native to Asia and introduced accidentally to North America around 1920. It is now found in much of the eastern US as an aggressive forest invader. Despite its delicate appearance, stiltgrass can spread quickly into large, dense infestations. It is very shade



tolerant and often found spreading along forested roads, trails, and streams, but is also able to colonize a variety of open habitats, including roadsides and even residential lawns. In Indiana, this invasive is widespread in the southern part of the state, but becomes more scattered in central and northern counties. This presentation will include an overview of the species, the unique challenges faced by land managers battling it in southern Indiana, and control options and timing.

### **EDDMapS Pro Mapping Applications Aid in Early Detection and Rapid Response to Potential Pest Threats**

*Tricia Bethke; The Morton Arboretum*

Learn how to use EDDMapS Pro for early detection, rapid assessment of potential invasion threats, as well as a rapid response to invasions like the spotted lanternfly. In Illinois, a community network of trained volunteers mapped the distribution of tree of heaven in support of the EDRR spotted lanternfly program. This presentation will highlight the EDDMapS Pro mapping and monitoring program, identification of high-risk pathways, and education and outreach efforts to engage local communities in early detection to increase awareness and expand the number of people looking for spotted lanternfly.

### **Biocontrol of Tree of Heaven (*Ailanthus altissima*) in an Integrated Management Plan**

*Francesca Marini*<sup>\*1</sup>, *Massimo Cristofaro*<sup>1</sup>, *Enrico de Lillo*<sup>2</sup>, *Radmila Petanović*<sup>3</sup>, *René Sforza*<sup>4</sup>, *Biljana Vidović*<sup>3</sup>, *Philip Weyl*<sup>5</sup>; <sup>1</sup> Biotechnological and Biological Control Agency; <sup>2</sup> University of Bari Aldo Moro; <sup>3</sup> University of Belgrade; <sup>4</sup> USDA-ARS European Biological Control Laboratory; <sup>5</sup> CABI

Tree of heaven, *Ailanthus altissima* (Simaroubaceae), is native to China and was introduced to North America as early as 1784 as an ornamental tree. It is now considered an invasive tree in several states in the US and parts of Canada. Since chemical and mechanical methods have shown their limits, a biological control program was initiated in the early 2000s. However, to date, no biocontrol agents have been released against this species in North America and other countries as well. During surveys in Europe, where tree of heaven is also an alien species, an eriophyid mite, *Aculus mosoniensis*, was recorded. This mite appeared to be severely damaging seedlings and impacting new growth in spring. Preliminary host range testing, on eight plant species closely related to tree of heaven, showed promising results for considering this mite as a new potential biocontrol agent in North America. A larger test plant list is being developed which will also consider more temperate species from Canada. Since the mite is effective at reducing the fitness of young trees, investigations in the biology and use of this species in an integrated management plan are also in progress. Indeed, pilot studies are underway to evaluate if control can be achieved when large trees are cut back then followed by direct inoculation of mites on re-sprouting plants. We believe that if *A. mosoniensis* is specific enough for release into North America, it will contribute to an effective integrated management strategy with long term benefits in the invasive range.

### **NAISMA Certified Weed Free Mulch Standards: A New Tool for a Critical Invasive Species Pathway**

*Elizabeth Brown\** and *Belle Bergner*; North American Invasive Species Management Association

The NAISMA Weed Free Forage and Gravel (WFFG) program is the only program in North America that provides land managers with assurance that noxious weeds will not be spread through the movement of forage, hay, mulch, or gravel brought into the property. Many federal, state, and local lands require the use of certified weed free forage and gravel on their properties. At the time of this abstract, Certified Weed Free Mulch Standards are in development with significant input from the Mulch and Soil Council and major financial support from USDA APHIS. Mulch standards are expected to be complete and ready for adoption by Fall 2020. This presentation will explain the Weed Free Mulch Standards, how Upper Midwest government agencies can participate and have their inspectors trained, and how mulch producers can get involved.

## **Invasives & Restoration 1:**

### **Grazing & Shading as Tools for Restoration & Invasive Control**

#### **Cover it Up! Four Years of Restoring Herbs to Control Common Buckthorn**

*Peter Wragg\*<sup>1</sup>, Michael Schuster<sup>1</sup>, Lee Frelich<sup>1</sup>, Alex Roth<sup>2</sup>, Paul Bockenstedt<sup>3</sup>, Shawn Schottler<sup>4</sup>, Mike Goodnature<sup>5</sup>, Paul Kortebein<sup>6</sup>, Peter Reich<sup>1</sup>; <sup>1</sup> University of Minnesota; <sup>2</sup> Friends of the Mississippi River; <sup>3</sup> Stantec; <sup>4</sup> St. Croix Watershed Research Station; <sup>5</sup> Ramsey County; <sup>6</sup> Three Rivers Park District*

This project seeks to improve management of the invasive shrub common buckthorn (*Rhamnus cathartica*) by developing strategies to constrain buckthorn recolonization after removal. Buckthorn receives much management attention in the upper Midwest because it forms monospecific stands, reduces plant and animal diversity, interrupts forest regeneration, and hosts agricultural pests. However, long-term buckthorn control is frequently ineffective because buckthorn rapidly re-establishes from seeds and re-sprouts. Following buckthorn removal, we hypothesize that re-establishing vigorous native vegetation by seeding native herbs (grasses, sedges and wildflowers), combined with follow-up foliar herbicide, can limit re-invasion by taking up light and other resources that buckthorn would otherwise exploit and augment fuel for prescribed fire. We are using a large-plot experiment to test how factorial combinations of seeding a diverse herb mix and selective follow-up fosamine (Krenite) herbicide application affect buckthorn recolonization at seven sites around Minneapolis/Saint Paul, Minnesota. We present results from the first four years of these experiments. Without follow-up herbicide, buckthorn (largely resprouts) rapidly overtopped seeded herbs. When combined with follow-up herbicide, seeded herbs - especially various wildryes (*Elymus* spp.) - have trended progressively more strongly in each succeeding year toward reducing light availability at ground level and reducing buckthorn seedling establishment; we will present new results from the 2020 field season. We also applied prescribed fire in replicate subplots at one site and found that seeded plots burned more completely and more intensely than unseeded plots. We will discuss how restoring native herbs can contribute to sustainable forest restoration strategies following buckthorn removal.

#### **The Effectiveness of using Targeted Grazing for Vegetation Management: A Meta-Analysis**

*Katherine Marchetto\*, Tiffany Wolf, Daniel Larkin; University of Minnesota*

The use of targeted grazing to control undesirable plants as a component of ecological restoration is gaining in popularity, but there is considerable uncertainty among land managers about the effectiveness of this approach. We synthesized existing literature on the use of livestock to control undesirable plants using a meta-analysis to characterize the data that are currently available to address questions about the effectiveness of the approach. Fifty-nine studies matched our inclusion criteria, consisting of 85% peer-reviewed journal articles and 15% grey literature. Studies were conducted in 15 countries overall but concentrated in the United States and Europe. Cattle, goats, horses, and sheep were used for vegetation management in the studies. Most target plant species were non-native perennial forbs. Median study duration was 3 years, with a maximum of 10 years. We found that, overall, the use of targeted grazing does have a significant negative effect on undesirable plants and a significant positive effect on plant species richness and abundance. However, there was not consistent support for several targeted grazing recommendations, such as using high stocking densities and intensities. Ultimately, more research is needed to address a greater range of considerations, such as disentangling defoliation vs. plant mortality impacts and separating the contributions of native vs. non-native species to gains in plant species richness.

## Using Sheep to Control Buckthorn, Honeysuckle, and Garlic Mustard

Angela Miner; *The Nature Conservancy*

Common buckthorn (*Rhamnus cathartica*), Bush Honeysuckle (*Lonicera* spp), and Garlic Mustard (*Alliaria petiolata*) are among many species of invasive plants plaguing our wooded landscapes in Minnesota. There are several tools available for land managers to help control these species, and methods of biological control have become of increasing interest to reduce costs, chemical output, equipment damage, and personnel time. In this presentation, I will give an example of a lesser known tool for these woodland invaders- sheep grazing. Goats are becoming more common as a brush biological control; however sheep aren't readily recognized for their potential in open woodland/oak savannah restoration understories. In this talk, I will explore the successes, challenges, and learning opportunities of utilizing sheep grazing as a control mechanism for common buckthorn, bush honeysuckle, and garlic mustard in an oak savannah restoration.

## Suppression of *Phalaris arundinacea* by Assisted Succession: A 16-Year Restoration Experiment

Kattia Palacio-Lopez\*, Steve Hovick, Kali Mattingly, Leah Weston, Nathaniel Hofford, Logan Finley; *The Ohio State University*

Reed canary grass (*Phalaris arundinacea*) is a long-lived perennial grass native to Eurasia and an aggressive invader of North American wetlands. Abiotic factors such as disturbance, changes in hydrological regime and nutrient runoff enhance *Phalaris* establishment and vegetative spread, resulting in monospecific stands with loss of diversity and altered ecosystem function. Heavy shading reduces *Phalaris* success, so a potential long-term restoration strategy is the establishment of woody plants that out-compete the grass by limiting light availability. To determine a suitable combination of native woody species that might control *Phalaris*, we established a swamp forest restoration study in 2003, establishing five pre-planting treatments in a *Phalaris* monoculture: late fall herbicide only, herbicide+burn, herbicide+plowing, herbicide+mowing, and control. We planted 23 trees and shrubs and evaluated their initial survival for two years. Then, in 2019, we re-surveyed the site to (1) evaluate the effect of our treatments on community composition and (2) generate a list of species to plant for longer-term restoration purposes. We found that the establishment of a woody plant community successfully reduced *Phalaris* density, with all treatments yielding <5% *Phalaris* cover). The top 5 groups of woody species that dominated the developing forest community are Ash, Tamarack, American Elm, Dogwood, and Slender Willow. Given the high sensitivity of wetlands to plant invasion, management strategies that combine physical and chemical methods are important. Furthermore, we show an effective and relatively low-cost method for establishing native woody species and restoring swamp forest in wetlands dominated by *Phalaris*.

## TUESDAY AFTERNOON CONCURRENT SESSIONS

### **Genetic Biocontrol: Science, Policy, Ethics & Outreach**

#### **Engineering Genetic Biocontrol Agents for Terrestrial and Aquatic Invasive Species**

*Michael Smanski; University of Minnesota*

We introduce a novel approach to engineer a genetic barrier to sexual reproduction between otherwise compatible populations. Programmable transcription factors drive lethal gene expression in hybrid offspring following undesired mating events. In this talk, I describe the technology, demonstrate a proof-of-concept in yeast and in insects, and share recent progress in translating the approach to invasive species with applications for pest control.

#### **Gene Drive: A Novel Tool for Non-Native Invasive Plant Management**

*Alan Smith\*, Nicholas Johnson, Roger Becker, Neil Anderson; University of Minnesota*

We will discuss what gene drive is, how it could be applied to invasive plant management and its risks / benefits. Gene drives use a CRISPR-CAS system (Clustered regularly interspaced short palindromic repeats-CRISPR associated) that is capable of altering specific gene functions in a plant and can be self-propagated through a population. The specificity of a CRISPR-CAS system comes from an integrated guide RNA that targets gene alteration to a specific sequence in the plant's genome. The CRISPR-CAS system has proven effectiveness and been used to improve crops from mushrooms to soybeans. In theory, gene drives could be developed to target genes that would reduce fertility, prevent flowering, alter sex expression so only male plants were produced, reduce competitiveness or alter any invasive characteristic where the sequence of a gene target is known. *Tanacetum vulgare* (common tansy) is an ideal invasive plant to assess the risk and benefits of a possible gene drive control strategy and would address long-standing management challenges. With 36,305 reports in EDDMapS, common tansy is one of the most frequently reported invasive plants in Minnesota. With such extensive distribution, herbicide control would be inefficient, ineffective, expensive, and is often limited due to non-target issues. Development of biological control for common tansy is ongoing, but requires extensive testing for each bioagent and may have limited effectiveness and risks from a lack of host specificity. The biology of common tansy and presence of close relatives in North America makes gene drive an ideal management strategy.

#### **U.S. and Other Policy Considerations Relevant to Invasive Species Control**

*Stas Burgiel, National Invasive Species Council Secretariat*

In 1986, the Coordinated Framework for the Regulation of Biotechnology was developed to help facilitate the review and ensure the safety of biotechnology products under the relevant regulatory authorities of the Animal and Plant Health Inspection Service (APHIS), the Environmental Protection Agency (EPA), and the Food and Drug Administration (FDA). From 2015 to 2017 an update of the Coordinated Framework was conducted to bring it in line with advances in the field of biotechnology.

Key objectives for the update included clarifying: which biotechnology product areas are within the authority and responsibility of each agency; the roles each agency plays for different product areas, particularly for those products that fall within the scope of multiple agencies; a standard mechanism for communication and coordination among agencies; and the mechanism and timeline for regularly reviewing and updating the

Coordinated Framework. During this process a National Strategy for Modernizing the Regulatory System for Biotechnology Products was developed to identify future steps to ensure the regulatory system addresses novel types of products developed through advances in science and technology. The National Academies of Science, Engineering, and Medicine were commissioned by the three regulatory agencies to conduct an independent study (Preparing for Future Products of Biotechnology) to identify: major advances and potential new types of biotechnology products over the next five to ten years; potential future products that might pose a different type of risk relative to existing products and organisms; areas in which the risks or lack of risk relating to biotechnology are well understood; and the scientific capabilities, tools, and expertise that may be useful to the regulatory agencies. For invasive species applications, other laws and policies may be relevant outside of those explicitly covered by the Coordinated Framework. These could include the National Environmental Policy Act, the Endangered Species Act, the authorities of federal land-management agencies, state and local regulations, as well as international environmental and trade law.

### **Thinking Beyond the Federal Framework Governing Genetic Biocontrol: Legal and Policy Considerations from the International to Local Scale**

*Stephanie Otts; National Sea Grant Law Center, University of Mississippi*

This presentation will discuss the need for policy-makers at the national and state level to consider the implications of their decisions with respect to genetic biocontrol and synthetic biology more generally at both the international and local scale. Following a brief overview of the key international treaties and institutions, this presentation will highlight several general principles of international law relevant to the governance of synthetic biology including the precautionary approach, duty to prevent transboundary harm, and indigenous peoples' rights to self-determination. As synthetic biology moves from the laboratory to the field, questions will arise regarding community engagement and local decision-making. This presentation will conclude with a discussion of emerging governance models including the experience in Florida regarding the Oxitec mosquito field trials.

### **Engaging the Public when Biotechnology Goes "Wild"**

*Jason Delborne; North Carolina State University*

Developments in synthetic biology - including advanced gene editing techniques, gene drives, and genetic biocontrol strategies - offer new opportunities for species conservation and ecological restoration. While most of these emerging technologies will trigger oversight by state and federal agencies, there is increasing recognition that their successful deployment will require more than regulatory approval. Recent reports by the National Academies of Sciences, Engineering, and Medicine on gene drives (NASEM, 2016) and forest biotechnology (NASEM, 2019), as well as the International Union for Conservation of Nature's report, Genetic Frontiers for Conservation: An assessment of synthetic biology and biodiversity conservation (IUCN, 2019), have highlighted the importance of conducting community, stakeholder, and public engagement well before a final product is presented as a management option. This presentation will review the theory and motivations for engaging publics on controversial technology with particular attention to two case studies. First, the author has conducted interviews and a stakeholder workshop surrounding the genetically engineered American chestnut tree. This biotech tree has been developed to resist the blight that caused its functional extinction in the twentieth century. The GE chestnut has gone through extensive field trials and is under review by the U.S. EPA, USDA, and FDA - if successful, it will be the first GMO designed to spread and persist in "wild" environments. Second, the author is part of the international consortium "Genetic Biocontrol of Invasive Rodents" (GBIRD), which is exploring the possibility of developing a gene drive mouse for biodiversity protection. The mouse is designed to eradicate populations of invasive mice on oceanic islands. The author has conducted a landscape analysis and a stakeholder workshop to inform the design, development, and safety testing of the gene drive mouse (which does not yet exist).

## **Big Data! Invasive Species Mapping Tools**

### **Wild Spotter - Mapping Invasives in America's Wild Places**

*Chuck Barger<sup>1\*</sup>, Rachel Carroll<sup>1\*</sup>, Mike Ielmini<sup>2</sup>, Pat Conzemius<sup>3</sup>, Dane Huinker<sup>3</sup>; <sup>1</sup> University of Georgia; <sup>2</sup> USDA - Forest Service; <sup>3</sup> Wildlife Forever*

Organizations across the U.S. have collaborated to create a unique nationwide citizen science volunteer capacity-building program called Wild Spotter™ to boost local capacity against invasive species. Wild Spotter™ goes beyond just tracking locations of any aquatic or terrestrial invasive species, it is designed to help recruit, train, and empower volunteers to provide critical information on invasions, share data, raise awareness, and teach the public about how they can prevent the spread of invasive species. It's innovated and advanced technology helps the public identify, locate and map aquatic and terrestrial invasive species in designated wilderness and other wild places across the U.S. The program's customized FREE mobile App for Apple and Android devices make it easy for anyone to use. Other custom-designed Wild Spotter™ components can be tailored to meet the needs of a local area and included a unique marketing component to promote partnerships across the landscape; showcasing the invasive species work of any group; raising public awareness; and coupling public and private data into a seamless system. All Wild Spotter™ data gathered is first validated by professionals, shared publically, and helps quantify the extent and impact of targeted invasive species to aid in restoring invaded areas. If you want to become a Wild Spotter™ volunteer or partner with the U.S. Forest Service on citizen science, visit the website: [www.wildspotter.org](http://www.wildspotter.org) . Download the free mobile Apps, and 'Like' us on Facebook.

### **The USGS NAS Database: Actionable Tools and Data for AIS Management**

*Matthew Neilson\*, Daniel Wesley, Ian Pfingsten; U.S. Geological Survey*

The U.S. Geological Survey's Nonindigenous Aquatic Species (NAS) Database is the primary source for spatially referenced nonnative aquatic species data nationwide. The program tracks the distribution of >1,330 freshwater and marine taxa (fish, crustaceans, mollusks, mammals, reptiles, amphibians, and obligate aquatic plants) in the contiguous U.S., Alaska, Hawaii and island territories. The NAS interactive website allows users to perform a variety of queries, download data, view informational summaries of species biology, and provides information on status and trends of nonnative species. This presentation will highlight the NAS program's recent efforts on building actionable tools and maps for managers and stakeholders to understand and manage species introductions. A few of the tools the program has created include Flood and Storm Tracker (FaST) maps, which evaluates the potential spread of nonnative species within and across drainage basins due to flooding. The Alert Risk Mapper (ARM) tool, which identifies stream and waterbodies at risk of invasion from new nonnative sightings and is delivered with NAS Alert emails sent out to subscribers. The Screen and Evaluate Invasive and Nonnative Data (SEINeD) tool can rapidly identify nonnative species occurrences and perform geospatial QA/QC on tabular data. The program has recently begun compiling a systematic literature review of ecological, economic, and human health impacts of invasive and nonnative species that are being synthesized into easy to access tables on the NAS website.

### **ISMTrack: Easing Coordination for Long-term Management of Invasive Knotweeds (*Polygonum* spp.)**

*Christina Basch<sup>\*1</sup>, Monika Chandler<sup>1</sup>, Chuck Barger<sup>2</sup>, Barb Perry<sup>3</sup>, Edward Dittmer<sup>4</sup>, Dustin Looman<sup>4</sup>; <sup>1</sup> Minnesota Department of Agriculture; <sup>2</sup> University of Georgia; <sup>3</sup> Minnesota Department of Natural Resources; <sup>4</sup> Conservation Corps of MN & IA*

In 2019 and 2020, the Minnesota Department of Agriculture (MDA) and Department of Natural Resources utilized the ISMTrack mobile application in the field for documenting over 100 targeted herbicide treatments for

Japanese (*Polygonum cuspidatum* Siebold & Zucc.) and bohemian knotweeds (*Polygonum x bohemicum* (J. Chrtek & Chrtkova) Zika & Jacobson). The ISMTrack app permitted recording invasive species management on location and in real time, which increased the ease, accuracy and completeness of data collection. Storing this information in ISMTrack allows data-sharing between departments, project partners, and other stakeholders. Crews were able to enter data on-site post treatment, and then navigate to the next location from their site list shown in the app. Utilization of this app reduced the time spent by the site manager for preparation and backend data entry, allowing for more organized and streamlined treatments.

### **Focus on the Audience, Not the Technology**

*Chuck Barger\*, Rebekah Wallace, Rachel Carroll, Joe LaForest; University of Georgia*

EDDMapS, North America's leading resource for reporting occurrences of invasive species, is getting its biggest update in over a decade. Whereas previous iterations of the EDDMapS website and smartphone applications focused on regional needs (and, thus, regional versions of each existed), the new EDDMapS unifies regions into one collective website and app. Concurrent to this, the EDDMapS API has also been redesigned for improved performance, increased usability, and easier implementation with a broader user base. This will allow for easier and more precise data sharing among individual users and aggregate databases alike. As well as launching other interfaces for specific user group including Wild Spotter, IveGot1 and AgPestMonitor. EDDMapS has been a resource for invasive species occurrence data since 2005. In this time, EDDMapS has grown from a citizen science database focused on invasive plant data in the southeast to an aggregate database soliciting data on all invasive species taxa and biological control agents across the US and into Canada. As technology has advanced, it has allowed for more features and tools to be developed and made available to EDDMapS' partners. This presentation will: 1) give an overview of EDDMapS, Wild Spotter, IveGot1, and AgPestMonitor; 2) instruct participants on how to access these systems on their browser and smartphone; and 3) answer questions about merging data from multiple platforms.

## **Assessing & Addressing AIS Risks**

### **Aquatic Plant Pathway Risk Assessment for the Laurentian Great Lakes**

*Ceci Weibert\*<sup>1</sup>, Erika Jensen<sup>1</sup>, Lindsay Chadderton<sup>2</sup>, Andrew Tucker<sup>2</sup>, Kate Wyman-Grothem<sup>3</sup>; <sup>1</sup> Great Lakes Commission; <sup>2</sup> The Nature Conservancy; <sup>3</sup> U.S. Fish and Wildlife Service*

Non-native and potentially invasive aquatic plants are moved throughout the Great Lakes region and may be introduced to natural waterways through a variety of pathways. In an effort to understand the primary pathways of movement for aquatic plants and their associated risks, a pathway risk assessment was conducted using methods adapted from draft guidance developed by the U.S. Aquatic Nuisance Species Task Force. The assessment included three phases: multiple pathway triage; pathway definition; and pathway risk analysis and ranking. Using this approach, eight priority pathways were defined and selected for analysis: aquaculture of fish/aquatic animals; aquatic recreation gear; bait, bait collection, and use; fish hauling, movement, and stocking; pet/aquarium trade; plant trade; recreational boats and vehicles; and sampling and management equipment. A risk analysis questionnaire was distributed to pathway experts throughout the Great Lakes region to characterize pathway activity for invasive aquatic plants; determine whether certain activities are associated with high risk plant species; and identify gaps in management, compliance and law enforcement, and education. Preliminary knowledge gaps identified as barriers to effective management include which species move through what pathways, how pathways are interconnected, and the extent to which different user groups comply with regulations that are designed to limit the movement of aquatic plants. This presentation will review the methods used, preliminary results, and lessons learned.

### **Online Decision Support Tool to Prioritize AIS Surveillance and Watercraft Inspection Activities**

*Nicholas Phelps<sup>\*1</sup>, Amy Kinsley<sup>1</sup>, Robert Haight<sup>2</sup>, Petra Muellner<sup>3</sup>, Ulrich Muellner<sup>3</sup>, Zoe Kao<sup>1</sup>, Eva Enns<sup>1</sup>; <sup>1</sup>University of Minnesota; <sup>2</sup>USDA - Forest Service; <sup>3</sup>Epi-Interactive*

Aquatic invasive species (AIS) managers are tasked with preventing the spread of many AIS moving through a highly complex and interconnected system, often with limited resources to do so. Using a data-driven approach to identify and prioritize waterbodies at high risk of invasion can help inform effective and efficient programs. To that end, we have created the Minnesota AIS Explorer, an online user-friendly decision support tool for local and state managers. The first feature of the AIS Explorer visualizes lake-level risk estimates for the introduction and establishment for zebra mussels and starry stonewort for all lakes in Minnesota. This was created with a multi-layer network model that consisted of watercraft movement and natural water connectivity, and environmental suitability models. The tool can be used to inform strategic surveillance planning at various spatial scales to prioritize locations at the greatest risk of AIS establishment. The second feature of the AIS Explorer is an interactive dashboard for county-level allocation of watercraft inspectors that optimizes the number of risky boats (leaving infested waterbody, arriving at uninfested waterbody) that are inspected. The tool allows users to define management objectives (percent of risky boats inspected), select species of interest (zebra mussels, starry stonewort, Eurasian watermilfoil and/or spiny waterflea), and lakes of interest (opt in/opt out). Early versions of these two features have been piloted by county AIS managers and recommendations incorporated into the tool. The science behind the AIS Explorer and a demonstration of the tool will be provided as part of the presentation.

### **Assessing the Risk of Fish Pathogen Introduction via Illegal Release of Live Baitfish in Minnesota**

*Meg McEachran\*, Janice Mladonicky, Catalina Picasso, Nicholas Phelps; University of Minnesota*

The release of live fish used as bait by recreational anglers has been identified as a high-risk pathway for the spread of aquatic invasive species, including harmful fish pathogens, which may pass undetected in otherwise innocuous native species. Live bait release is consequently outlawed in several states, but compliance is less than perfect and estimates for release rate range from 20-40% of the millions of anglers that buy a license every year, resulting in millions of opportunities for pathogen introduction. The purpose of this study was to quantify the number of “risky trips,” or trips that result in the release of an infected baitfish, using a stochastic simulation model parameterized by angler survey data from Minnesota, USA. We simulated one year of fishing in Minnesota and calculated the total number of risky trips for each of three pathogens identified as high-risk: viral hemorrhagic septicemia virus, the microsporidian parasite *Ovipleistophora ovariae*, and the Asian fish tapeworm *Schizocotyle acheilognathi*. We assessed the number of risky trips under four scenarios: current/baseline conditions, outbreak conditions (increased pathogen prevalence), source-focused control measures (decreased pathogen prevalence), and angler-focused control measures (decreased rates of release). We found that under current conditions, hundreds of thousands of risky trips occur even at low pathogen prevalence. We also discuss the findings of the scenario simulations and make recommendations for future management strategy to reduce the risk of fish pathogen spread via this pathway.

### **How "Hidden Mitten" Exposed an Illicit Invasive Species Threat**

*Sharon Gary\* and Holli Polansky\*; U.S. Fish and Wildlife Service*

Over the course of 120 days in 2019, U.S. Fish and Wildlife Service Wildlife Inspectors stopped approximately 15,000 live Chinese mitten crabs from entering the country in smuggled shipments falsely declared as t-shirts, jeans, photo albums and other commercial products. The first investigation led by the Service's new Wildlife Inspection Interdiction Team, Operation Hidden Mitten exposed the magnitude of a serious threat to our



waterways. Chinese mitten crabs are one of North America's most invasive species, and in high densities, cause a number of problems: out-competing native species for resources; undermining flood levees and causing streambank erosion; clogging screens, pumps and water-intake structures at fish-collection facilities and power plants; and hurting commercial and recreational fishing industries by consuming bait, damaging nets and devouring catch. Not to mention a potential public-health risk: Chinese mitten crab is a carrier of Oriental lung fluke, a parasitic disease that can be transferred to humans through the ingestion of raw or undercooked crabs. The fluke has not been detected in mitten crabs collected within the United States yet. During the operation, the Service Wildlife Inspectors detained and destroyed illegal crabs imported at express courier hubs and major international airports across the nation. The Interdiction Team consisted of seasoned Service Officers who are focused on closing wildlife trafficking pathways, generating intelligence and coordinating national inspection efforts. During this talk, we will share what we learned from this investigation, and what we can do to help prevent the further import and spread of this highly invasive species.

### **Potential Sources of Infectious Disease Introduction: An Overview of the U.S. Live Exotic Aquatic Animal Trade from Asia**

Alexander Primus<sup>\*1</sup>, Amy Kinsley<sup>1</sup>, Tiffany Wolf<sup>1</sup>, Kristine Smith<sup>2</sup>, Carlos Zambrana<sup>2</sup>, Nicholas Phelps<sup>1</sup>; <sup>1</sup>University of Minnesota; <sup>2</sup>EcoHealth Alliance

Global wild/exotic animal trade serves as a risk factor for the spread of infectious diseases. In the United States, the majority of wild/exotic animal imports are comprised of aquatic organisms originating from Asia and may serve as a mechanism of infectious disease transmission to the country's diverse and growing aquaculture industry. In this study, we describe fourteen years (2000-2013) of live aquatic animal trade to the United States from Asia recorded in the Law Enforcement Management Information System database. We identify potential pathogens of concern and characterize the risk that importing countries may pose on the aquaculture industry based on trade volume and disease status of exporting country. We found that while the majority of shipments are sent from the Philippines, the majority of organisms are sent from Singapore, and the majority of both shipments and organisms are received by the port of Los Angeles. Additionally, we found that the majority of imports were comprised of freshwater tropical fish, but a lack of standardized taxonomic nomenclature in the database hindered the pursuit of a standardized risk assessment. We identified 25 potential pathogens of concern which affect finfish, crustaceans, and mollusks. Compared to other countries included in the study, Singapore poses the highest risk of introducing a pathogen of concern for both finfish and crustaceans. However, due to the lack of knowledge and uncertainty surrounding taxonomic classification and location of movement after importation, more work is warranted to develop a deeper understanding of the risks to the aquaculture industry.

### **Insect Pests of Forest and Agricultural Lands**

#### **Host Preferences of Velvet Longhorned Beetle, *Trichoferus campestris***

Grace Haynes<sup>\*1</sup>, Marissa Streifel<sup>2</sup>, Angie Ambourn<sup>2</sup>, Brian Aukema<sup>1</sup>; <sup>1</sup>University of Minnesota; <sup>2</sup>Minnesota Department of Agriculture

Invasive woodboring beetles, such as emerald ash borer, *Agrilus planipennis* (Coleoptera: Buprestidae), and Asian longhorned beetle, *Anoplophora glabripennis* (Coleoptera: Cerambycidae), have been known to cause widespread damage to forests, industry, and property. Velvet longhorned beetle (VLB), *Trichoferus campestris* (Coleoptera: Cerambycidae), is a frequent target in early detection/rapid response surveys. It was first detected in North America in 1997 and has established in several states, such as Utah, Minnesota, Wisconsin, and Illinois. Research from the insect's native range in Russia indicates the ability to infest many hosts and the ability to

colonize both healthy trees and extremely dry wood. To date its impacts in North America have been inconsequential, but little data exists on its behavior in its introduced range. This study explores ovipositional preferences and larval performance of *T. campestris* on various cut logs of potential host species. Our goal is to collect data to inform risk analyses and management goals should they become necessary.

### **The History of Gypsy Moth (*Lymantria dispar*) Management in Wisconsin: From Weather Balloons to iPhones**

*Christopher Foelker; Wisconsin Department of Agriculture, Trade & Consumer Protection*

Detection and control of gypsy moth (*Lymantria dispar*) spread has been an ongoing forest pest management effort in Wisconsin for almost a half century. Gypsy moth was first detected in the state in 1971, but didn't become firmly established until almost twenty years later in the easternmost counties. Currently, gypsy moth is an entrenched pest in the eastern and central counties and is slowly spreading into the most western counties of the state. Management of this insect has advanced through many different phases, both technological and programmatic. The two core components of managing the spread of gypsy moth are trapping and treatment along the infestation's leading edge. A key factor in the success of this program through the years has been the data and evidence-based approach to decision-making. Additionally, there are multiple state and federal agencies that successfully coordinate resources and knowledge to accomplish this massive regional-scale program to slow the spread of gypsy moth.

### **Gypsy Moth (*Lymantria dispar*) Program Updates on Surveys and Treatments**

*Natasha Northrop; Minnesota Department of Agriculture*

The gypsy moth is one of North America's most destructive tree pests. The Minnesota Department of Agriculture (MDA) has statutory authority and responsibility to prevent the introduction and limit the spread of terrestrial plant pests, such as gypsy moth. The MDA conducts annual surveys for early detection and follow-up treatment programs to slow the spread and establishment of gypsy moth into the state of Minnesota, thus protecting the state's natural and urban forests, local property values, and vital tourism industry. Currently gypsy moth is only "established" in northeastern Minnesota's Lake and Cook Counties - both counties were put under state and federal quarantine in 2014. There are 85 MN counties in which gypsy moth is not yet established. This presentation will provide current information on gypsy moth population movement into Minnesota and management efforts to slow the spread and minimize the impacts as a result of establishment of this invasive forest pest.

### **Cost-effective Organic Controls for Spotted-wing Drosophila: Bio-pesticides and High Tunnel Exclusion**

*Matthew Gullickson\*, Gigi DiGiacomo, Mary Rogers; University of Minnesota*

SWD or spotted-wing drosophila (*Drosophila suzukii*) has plagued Midwestern fruit growers for a decade now, causing substantial yield losses and management costs in the small fruit industry. Since then, growers have utilized a wide array of chemical and cultural control strategies, often with little information about horticultural or economic effectiveness. Research trials conducted at the University of Minnesota in 2017-2019 compared the percent of SWD-infested primocane raspberries, yields, and the economic cost-benefits of a weekly rotation of the organic insecticides spinosad (6 oz / acre, Entrust SC) and *Chromobacterium subtsugae* (3 lbs / acre, Grandevo WDG) to high tunnel exclusion. SWD infestation varied annually between season-long exclusion (3.6 - 48.7% fruit infestation) and open-field organic insecticide treatment (8.9 - 34.3% fruit infestation). The organic insecticides produced a greater return on investment and were more profitable compared to the non-organic insecticide, zeta-cypermethrin (4 oz / acre, Mustang Maxx), (control) and physical exclusion even when organic

price premiums for raspberries varied. In order to reduce the dependency on insecticide chemical control, the economics of other integrated pest management techniques must be investigated.

### **The Parasitoid *Aphelinus certus* as a Biological Control Agent of the Soybean Aphid**

*James Miksanek\* and George Heimpel; University of Minnesota*

The aphid parasitoid *Aphelinus certus* is native to Asia and was accidentally introduced into North America in recent decades. While it is a generalist in the sense that it attacks numerous aphid species, it is known almost entirely as a parasitoid of the soybean aphid, *Aphis glycines*, in North America. Since the soybean aphid is a major agricultural pest in the United States and Canada, and is also native to Asia, *A. certus* was seen as a potentially important biological control agent of this aphid. Indeed, it has emerged as one of the dominant natural enemies of soybean aphid in Minnesota, and an early experimental study showed that it has the ability to reduce soybean aphid densities below economically damaging levels. We built upon this work by conducting a series of field experiments and by parameterizing a matrix model to evaluate the effectiveness of *A. certus* as a biological control agent of the soybean aphid. The modeling study suggested that sufficiently high parasitism levels to suppress populations would be reached in approximately 10% of fields, but the field study showed that in-field parasitism at a number of sites in Minnesota between 2017 and 2019 were too low to suppress populations. Thus, while *A. certus* is a dominant natural enemy of soybean aphid in Minnesota soybean fields with potential to strongly suppress populations, parasitism levels are often too low for this potential to be achieved. Possible ecological mechanisms that reduce parasitism levels of this pest across Minnesota include poor overwintering and hyperparasitism.

## **Invasives & Restoration 2: Wetland Restoration - Successes with Cattail Invasions**

### **Invasive Species Before, During and After Restorations**

*Gina Quiram\* and Wade Johnson; Minnesota Department of Natural Resources*

In 2008 the Clean Water, Land and Legacy Amendment was passed in Minnesota allocating significant funding for restoration. Since then nearly 6,000 restoration projects have been completed using Legacy funds. The goal of the Legacy Fund Restoration Evaluation Program is to improve the quality of restorations through third party reviews of restorations relative to the law, current science and stated goals of the projects. After site visits, a panel of restoration experts reviews plans and field assessments. More than 150 evaluations have been completed in a variety of habitat types, including wetlands, prairies, forests, rivers, streams and lakeshores. Invasive species affect the majority of evaluated restorations as drivers of degradation, targets of management, obstacles of site preparation, or threats to the long-term restoration benefits. Based on findings from eight years of project evaluations, the expert panel has made seven recommendations for elevating restoration practice including improved restoration training, improved project documentation and use of multidisciplinary project teams. We advocate for strategic consideration of invasive species in training, project planning documents, composing project teams and throughout the restoration process to elevate restoration practice moving forward.

### **Restoration of Wetlands Infested with Hybrid Cattail in Voyageurs National Park**

*Reid Plumb\*<sup>1</sup>, Steve Windels<sup>1</sup>, Chandra Wiley<sup>1</sup>, Bryce Olson<sup>2</sup>; <sup>1</sup> National Park Service; <sup>2</sup> Russurs Consulting LLC*

Non-native cattails are known to disrupt ecosystem balance by creating dense monotypic stands which displace native species and reduce biological diversity. Hybrid cattail (*Typha x. glauca*) is the dominant plant species in

most wetlands in Voyageurs National Park, MN. We started a project in 2016 to reduce cattail abundance and restore wetlands to more diverse natural states. Lakes in Voyageurs National Park are designated as “Outstanding Resource Value Waters” where the use of herbicide is prohibited. We treated invasive hybrid cattails in invaded wetlands using 6 different mechanical treatment methods on Rainy Lake. We conducted pre- and post-treatment vegetation surveys of treated wetlands and compared percent vegetation composition for each treatment type. Total removal of cattail using heavy equipment was the most effective removal treatment method with the presence of cattail being reduced from 98% composition to 0%. Underwater cutting prior to the summer high water period and back piling of harvested material on remaining cattail stands were the 2nd and 3rd most effective treatments, respectively. Here, we will present an overall project update, preliminary findings, and direction of future work.

### **Wetland Restoration Implications of Invasive Plants and High Water Levels in the St. Louis River Estuary**

*Dustin Haines<sup>\*1</sup>, Anna Hall<sup>2</sup>, Hannah Ramage<sup>1,1</sup>, Lake Superior National Estuarine Research Reserve; <sup>2</sup> U.S. EPA*

Habitat reclamation and restoration efforts within the St. Louis River estuary are a high priority, due to St. Louis River Area of Concern delisting efforts, and to broad initiatives for restoring wild rice in the estuary. Efforts to restore native plant communities in wetlands here have been partially successful, but the presence of invasive plants such as purple loosestrife (*Lythrum salicaria*) and non-native cattails (*Typha angustifolia* and *T. x glauca*), and nearly record high Lake Superior water levels, may be hampering these efforts. To evaluate the relative influence of invasives and water levels on native plant success, we analyzed wetland vegetation data from 2014-2017 collected at the Lake Superior National Estuarine Research Reserve's Sentinel Site (an undisturbed area that has not undergone restoration). From 2014 to 2017, there was a significant decline in total and native vegetation cover, but no decline in invasive species cover. However, there were no significant changes in species richness and diversity over the years, and no correlations between native and invasive species cover, richness, or presence for any year. Water depth, meanwhile, was negatively correlated with cover and species diversity for nearly all years, regardless of nativity status. Our data highlights two important points: 1) the high water levels of Lake Superior may be the most important factor influencing wetland restoration efforts in the estuary, and 2) invasive plants may be more resistant to these high water conditions than most native species, giving them an advantage in both undisturbed and restored areas.

### **Removing Invasive Cattail to Restore Wild Rice in Allouez Bay**

*Kelly Beaster<sup>\*</sup> and Amy Eliot; University of Wisconsin - Superior*

In 2010, researchers and local stakeholders began attempts to restore wild rice to a shallow, protected embayment known as Allouez Bay, located at the southeast end of the St. Louis River Estuary in Superior, Wisconsin. It is not clear why wild rice disappeared from Allouez Bay, however, excessive herbivory, high turbidity, anthropogenic stress and invasive species are all likely suspects. Green wild rice seeded into the bay each fall reached maturity the following spring and fencing installed helped protect rice from herbivory. Although results were promising, restoration efforts were being hampered by rising water levels on Lake Superior and researchers noticed wild rice growing in areas of the vegetative mat where cattails were not present. To increase suitable habitat (water < 3 feet), monotypic stands of invasive hybrid cattail (*Typha x glauca*) were cut and removed by hand from the mat to provide open areas for seeding wild rice. Strips of cattail were left between cut patches to serve as natural barriers to browse. Some of the cut patches were protected with wire fencing to serve as comparisons for degree of herbivory. Accessible cut patches were monitored for presence/absence of wild rice and estimates show that 78% contained mature wild rice. This restoration trial provides evidence that areas invaded by invasive cattail can be converted to wild rice habitat if the cattail is controlled. Follow up surveys will be needed to determine if wild rice is able to out-compete invasive cattail long-term if left unattended.

## WEDNESDAY MORNING CONCURRENT SESSIONS

### **Workshop: Why Diversity, Equity and Inclusion are Vital to Conservation Goals**

Instructor: C. Parker McMullen Bushman; EcoInclusive Strategies, LLC

Diversity, equity, and inclusion have become buzzwords that have been placed strategically in organizational mandates, inspired the formation of DEI committees, and/or simply sparked critical dialogue around bias and organizational culture. But do we know what these words really mean and how do we put this work into action in the environmental field. In this session participants will understand the relationship between culture and bias, learn about ways to incorporate DEI principles into our work and the importance of creating welcoming spaces so that all people may become environmental stewards who will advocate for and protect our most precious public resources – our land, water, trees, open spaces and wildlife.

Workshop objectives include: An overview of DEI principles; Looking at changing demographics and implications for conservation work; Exploring definition of unconscious bias and the cognitive processes which enable it.

### **Ballast Water: New Policies, Actions & Findings**

#### **Predicting the Risk of Pathogen Introduction from Ballast Water Discharge into the St. Louis River Estuary, Minnesota**

*Julia Zimmer\*, Randall Hicks, Chan Lan Chun; University of Minnesota - Duluth*

Many aquatic invasive species found throughout the Laurentian Great Lakes have been introduced by commercial ship ballast water discharge. However, less effort has been put towards monitoring and understanding the introduction and transportation of potentially harmful and invasive bacteria in these ecosystems. This study's aim is to determine the introduction and prevalence of the bacterial pathogen *Piscirickettsia salmonis* in Duluth-Superior Harbor (DSH) and St. Louis River estuary water using 16S rRNA amplicon sequencing and quantitative PCR analysis. Seventy-nine sites were sampled during summer 2019 in three categories: 1) commercial docks known for high rates of ballast water discharge, 2) estuary zones suspected to be common muskellunge (*Esox masquinongy*) habitats, and 3) random sites as environmental controls. Water from 24 ship ballast tanks were previously sampled and DNA sequenced by targeting the V4-V5 regions of the 16S rRNA gene. DNA was present from over 40 bacterial genera that contain human, wildlife, and/or ecologically or economically disruptive bacterial species. Of these, the genus *Piscirickettsia* is of great concern because *P. salmonis* is the suspected pathogen that caused muskellunge fish kills in Lake St. Clair during the mid-2000s. Preliminary qPCR results suggest detectable amounts of this pathogen in ballast water samples. Currently, there are no known instances of muskie pox in the DSH, but if *P. salmonis* was introduced, then it might harm the trophy muskellunge fishery there.

#### **Great Waters Research Collaborative's Journey to Find Effective Ballast Water Management Strategies**

*Kelsey Prihoda\*<sup>1</sup>, Meagan Aliff<sup>2</sup>, Kimberly Beesley<sup>1</sup>, Lana Fanberg<sup>1</sup>, Steven Gebhard<sup>1</sup>, Holly Wellard Kelly<sup>2</sup>, Marylee Murphy<sup>1</sup>, Christine Polkinghorne<sup>1</sup>, Euan Reavie<sup>2</sup>, Elaine Ruzycki<sup>2</sup>, Heidi Saillard<sup>1</sup>, Heidi Schaefer<sup>1</sup>, Tyler Schwerdt<sup>3</sup>, and Matthew TenEyck<sup>1</sup>; <sup>1</sup> University of Wisconsin - Superior; <sup>2</sup> University of Minnesota - Duluth; <sup>3</sup> AMI Consulting Engineers*

Although several vectors for introduction of aquatic nuisance species (ANS) exist within the Laurentian Great Lakes, e.g., organisms in trade and water recreation, commercial shipping accounts for the majority of known invasions since the opening of the St. Lawrence Seaway. For greater than ten years, scientists from the Great Waters Research Collaborative (GWRC) have been generating independent data on ballast water management

strategies that may reduce the environmental risk (i.e., reduction of propagules) in ballast water discharge. Strategies include ballast water management practices, which are currently being utilized by vessels in the U.S. and Canadian Great Lakes fleets, and ballast water treatment technologies that are currently being utilized globally by seagoing vessels. Prototype treatment technologies are researched by GWRC during laboratory testing, and as development of these technologies progresses, the scale of testing moves to land-based, and finally, shipboard testing. Development of ballast water treatment technologies for the Laurentian Great Lakes has been slow relative to technologies developed for seagoing vessels, due to the small market and unique water quality and vessel characteristics. In the short term, there may be ballast water management practices that could be effective at reducing the environmental risk associated with ballast water discharge. Potential effective short-term options will be presented, in addition to treatment technology types that may be promising in the long-term. Data gaps and research needs will be discussed, along with future research that will allow GWRC to continue their quest for effective ballast water management strategies.

### **Bench-scale Evaluation of Ballast Water Treatment for Bacterial Communities**

*Lisa DeGuire<sup>\*1</sup>, Matthew TenEyck<sup>2</sup>, Heidi Saillard<sup>2</sup>, Christine Polkinghorne<sup>2</sup>, Chan Lan Chun<sup>1</sup>, Randall Hicks<sup>1</sup>; <sup>1</sup> University of Minnesota - Duluth; <sup>2</sup> University of Wisconsin - Superior*

Ballast water has been identified as a major vector for the spread of invasive species, and the Duluth-Superior harbor (DSH) receives the most ballast water discharge of any port in the Laurentian Great Lakes. While most concern has focused on plant and animal invasive species, potentially harmful microbes have been largely overlooked. A bench-scale experiment was conducted to evaluate ballast water management practices as they relate to bacteria. Two common ballast treatment techniques (UV light and chlorination) were performed on ambient water collected alongside a lake freighter in the DSH, half of which was spiked with indicator bacteria. Culture-based and qPCR quantification of indicator bacteria and direct counts of total prokaryotic cells were performed immediately after treatment, as well as five days after treatment to check for bacterial regrowth. Both treatment techniques showed 99% reductions in culturable indicator bacteria in all samples immediately following treatment, but significant regrowth of *E. coli*, total coliforms, and heterotrophic bacteria occurred in the spiked samples after five days in both lab and field incubations. Initial qPCR results indicated that chlorination was the more effective disinfectant, but *E. coli* levels increased by 2 to 4 orders of magnitude within five days after treatment. Ongoing work to characterize total bacterial communities before and after treatment using 16S rRNA gene sequencing will help to determine if the treatment responses of indicator bacteria are similar to other bacterial genera harboring potentially harmful microbes.

### **Vessel Incidental Discharge Act (VIDA) – The U.S. Regulatory Framework for Discharges from Commercial Vessels**

*Jack Faulk\*, U.S. Environmental Protection Agency and Matthew A. Reudelhuber\*, U.S. Coast Guard*

The Vessel Incidental Discharge Act (VIDA) requires U.S. EPA and the U.S. Coast Guard to develop two future federal regulations to address commercial vessel discharges: 1. The EPA to develop national standards of performance by December 2020; and 2. The USCG to develop corresponding implementing, monitoring, and enforcement regulations two years thereafter. This presentation will provide a regulatory development progress update, as well as discussing the role of states, and opportunities for stakeholder engagement.

## **Ballast Water Management in the Great Lakes**

*Thomas Rayburn; Lake Carriers' Association*

Currently seven of the eight Great Lakes states, two U.S. federal agencies, and soon so will the Government of Canada regulate the management of ballast water. These regulations vary greatly in how they dictate the U.S. and Canadian Great Lakes fleet of vessels, known as lakers, manage their ballast water. Options available, sometimes contradictory, in existing permits and regulation include utilizing best management practices and the direct treatment of ballast water either on-board a vessel or employing off-vessel options. The U.S.-flag Great Lakes fleet has partnered with research and governmental organizations to explore options to handle ballast water and minimize or negate the inter-basin transfer of aquatic non-indigenous species, reducing the U.S.-flag fleet's "invasive species footprint." But vessel design, operating requirements, challenging waters of the Great Lakes, and regulatory conflicts are hurdles still being jumped. This presentation will focus on the actions Lake Carriers' Association and its members are taking in the management of ballast water.

Please note: This presentation may be subject to change based upon final regulations published by Transport Canada on their implementation of the International Maritime Organization's Ballast Water Convention and/or draft regulations published by the U.S. Environmental Protection Agency under the Vessel Incidental Discharge Act.

## **Legends of Forest Health: New Answers to Old Questions**

### **American Chestnut (*Castanea dentata*) as a Model for Tackling Introduced Pests and Pathogens**

*Keith Gilland; University of Wisconsin - Stout*

Introduced pests and pathogens are and will continue to be one of the greatest threats to existing plant diversity and future restoration efforts in temperate ecosystems. American chestnut (*Castanea dentata*) serves as an excellent example of an ecologically and economically important species brought to the brink of near-extinction by an introduced fungal pathogen (the chestnut blight; *Cryphonectria parasitica*). Historical efforts to restore American chestnut have included hybrid breeding programs, fungal biological treatments (hypovirulence), and the development of transgenic trees resistant to the chestnut blight. The final generations of the hybrid breeding program crossing American and Chinese chestnuts (*Castanea mollissima*) are currently being tested in large-scale progeny plantings to assess their ecological fidelity to their parental species, true blight resistance in field settings, and the effects of their reintroduction on blight dynamics and other ecological processes. Hypovirulent strains of chestnut blight fungus were initially identified in Europe as European chestnuts (*Castanea sativa*) recovered from the chestnut blight. Efforts in the United States to introduce a self-propagating hypovirulent strain of chestnut blight showed mixed success in field trials but may remain a component of larger restoration efforts. Finally, transgenic trees utilizing genes from wheat (*Triticum sp.*) to produce oxalic acidase neutralizing chestnut blight's cambium attack may provide another component in restoring American chestnut. Put together, these methods illustrate the complex approach that will be required to restore native species in the face of an increasing global pest and pathogen load in North American temperate forests.

### **Butternut Canker Disease: 50 years of Study and We Still Have Questions**

*James Jacobs; USDA - Forest Service*

Butternut canker disease, caused by the presumed introduced fungus *Ophiognomonia clavignenti-juglandacearum* has induced drastic changes to the distribution and abundance of butternut (*Juglans cinerea*) within its native range. The species short life-span, failure of forest management to provide adequate disturbance in eastern hardwood forests, and hybridization with the introduced nut tree Japanese walnut (*J. ailantifolia*), have all contributed to its extensive and steep population decline. However, butternut canker

disease remains the largest impediment to butternut restoration. The fungus causes small elliptical cankers and necrosis on all tissues. Cankers coalesce and kill branches and trees of all ages or contribute to eventual mortality caused by other pathogens (e.g. *Armillaria sp.*). In this presentation I will give a brief overview of the butternut canker pathosystem, discuss what researchers have learned in the 50 years since butternut canker disease was described and present future directions for research in the system and restoration of the species.

### **The Resurgence of Larch Casebearer in the Great Lakes Region**

Brian Aukema<sup>\*1</sup>, Spencer Stout<sup>1</sup>, Samuel Ward<sup>2</sup>; <sup>1</sup> University of Minnesota; <sup>2</sup> Mississippi State University

Larch casebearer is an invasive needle-mining insect that was accidentally introduced to the eastern United States in the late 1800s. It feeds on both eastern and western larch (*Larix spp.*). Severe or repeated defoliation can predispose trees to mortality from other pests such as eastern larch beetle. Following release of biological control agents from 1935 through the 1970s, larch casebearer populations decreased in western and eastern North America. In the past two decades, however, larch casebearer activity has resurged in the Upper Midwest region. This presentation discusses how a changing climate may be affecting larch casebearer populations.

### **Winning the Dutch Elm Disease Battle by Developing Resistant Elms for Minnesota**

Benjamin Held<sup>\*1</sup>, Chad Giblin<sup>1</sup>, Ryan Murphy<sup>1</sup>, Garrett Beier<sup>2</sup>, Robert Blanchette<sup>1</sup>; <sup>1</sup> University of Minnesota; <sup>2</sup> Farmingdale State College

For many decades the invasive pathogen *Ophiostoma novo-ulmi* has been decimating American elm (*Ulmus americana*) in Minnesota and across the country. American elm once lined streets across Minnesota, and for good reason. Its elegant form and tolerance to the harsh urban environment made it one of two premier canopy species, the other being green ash now threatened by the emerald ash borer. American, along with red (*U. rubra*) and rock (*U. thomasi*) elm, also provide critical benefits to wildlife and insects. Control measures so far have relied on sanitation and chemical control, which are both expensive methods considering the large numbers of trees affected. Another method, disease resistance has been identified in a small number of elms and holds great promise for bringing back American elm in the landscape. Genetic diversity, however, in resistant trees is needed to combat a pathogen with changing virulence. This is a critical time for the American elm, and a more expansive solution is needed to change the tide of this devastating invasive disease. The elm selection program at the University of Minnesota builds on years of research that has focused on natural disease resistance found in survivor elms. Through inoculation trials using clonally propagated material from trees identified across the state, we are testing disease resistance in American, red and rock elm. Mechanisms responsible for disease resistance have been studied and morphological and chemical defense characteristics in selected elms have been identified.

## **Invasives & Restoration 3: Terrestrial Restoration - Successes & Pollinator Benefits**

### **Influence of Landscape, Seeding Method and Management Practices on Invasive Plant Cover and Pollinator Plant Success Two Years After Planting**

Mark Renz<sup>\*</sup>, Yuebo Su, Jasmine Wyant, Erin Warner, Laura Judge; University of Wisconsin - Madison

Pollinator plant mixes are being planted on a wide range of landscapes using various seeding methods and invasive plant management approaches. Variable forb establishment success has been reported by stakeholders, but it is not clear what is driving failed establishment. Additionally, concern about invasive plant expansion in these pollinator



plantings is a concern. We visited 36 pollinator plantings throughout Wisconsin to assess the drivers of planted species success and invasive species cover. Cover of all species was evaluated in July and compared to 18 predictor variables using an exploratory analysis (random forest). Predictor variables included landscape attributes (habitat type, slope), prior land-use, soil attributes, seeding methods and management activities during establishment. Results found variable success in establishment of planted species with only 25 of the 88 species planted present in > 50% of planted sites. This resulted in an average planted forb cover of 5% and planted grass cover of 17%, but cover varied 2-3 fold across sites. Predictors did not explain total planted forb cover or density, but analysis of eight individual species found predictors varied considerably by species. Invasive species cover averaged 38% among sites with Kentucky bluegrass (39% cover), quackgrass (35% cover), Canada thistle (10% cover) and wild carrot (8% cover) the most common. Cover of invasive species was found to be related to presence of agricultural fields nearby (+), prior land use, % sand in soil (-), herbicide use prior to planting (worse), and weed management frequency during establishment. Results highlight the low success rate of many planted species and potential for establishment of invasive plants in establishing pollinator mixes.

### **Restoration of Native-Dominated Plant Communities on a Spotted Knapweed-Infested Site**

*Neil MacDonald, Grand Valley State University*

Restoring native-dominated plant communities often requires controlling invasive species, reintroducing native species, and implementing continued management practices. We studied the effects of site preparation (mowing, clopyralid, glyphosate), hand pulling of spotted knapweed (*Centaurea stoebe* L.), and burning on restoring native plant communities on a knapweed-infested site in Ottawa County, Michigan. We hypothesized that these treatments, alone or in combination, would control knapweed and encourage establishment and persistence of native species. Over eight years, we quantified the development of the plant communities on plots seeded with native grasses and forbs, and report on the second four years here. Native-dominated plant communities developed using both herbicides, but while clopyralid provided longer control of knapweed, clopyralid-treated plots had fewer native species than glyphosate-treated plots. Native-dominated plant communities also developed on plots that were only mowed once before seeding, achieving similar native species richness as the glyphosate treatment. Hand pulling controlled knapweed, burning increased relative cover of native graminoids and decreased that of non-native grasses, and hand pulling and burning in combination increased relative cover of native forbs. The restored plant communities had greater native species cover and richness and higher mean Coefficient of Conservatism, Floristic Quality Index, and Shannon's Diversity Index values than untreated areas. Site preparation, seeding, hand pulling of knapweed, and annual burning facilitated development of native-dominated plant communities that possessed many of the desired attributes of restored ecosystems. Effects accumulated over a period of eight years, illustrating the importance of continued management and monitoring as part of similar restoration efforts.

### **Best Management Practices for Pollinator-friendly Invasive Species Management**

*Baerbel Ehrig\* and Michele Sadauskas; Oneida County Land & Water Conservation Department*

Native bee and butterfly populations are plummeting rapidly due to habitat loss and pesticide use. With 35% of agricultural crops dependent on these pollinators, the Oneida County Land and Water Conservation Department (LWCD) became involved in creating and improving pollinator habitat as well as educational awareness of pollinator related topics. The Department also has a long-standing, strong aquatic invasive species program, and Michele Sadauskas, County Conservationist, Chairs the Wisconsin Headwaters Invasive Partnership (WHIP), a 3-county, terrestrial invasive group. While prioritizing pollinator conservation and invasive species management, we recognized that invasive species action groups could play a vital role in helping to protect, restore and create pollinator habitat. LWCD has already integrated pollinator-friendly practices into our invasive species management program and wondered how we could encourage other groups to do the same. For these reasons,

the LWCD developed Best Management Practices (BMPs) for pollinator-friendly invasive species management. Integrating educational outreach, chemical control, and restoration and conservation BMPs into an invasive species group's strategic plan or other guiding documents, is a positive step toward pollinator protection. This interdisciplinary approach guarantees the most success for pollinator conservation.

### **Long-term Impacts of Organic Soil Amendments on Urban Prairie Restoration**

*Leah Weston\*, Stephen Hovick, Scott Demyen, Nicholas Basta; The Ohio State University*

Ecological restoration is an important tool for improving ecosystem functioning in degraded, urban landscapes. Urban soil is often highly compacted, contaminated with pollutants and devoid of microbial activity. As a result, it is not conducive to supporting a diverse plant community or performing ecosystem services cities rely on. Organic soil amendments can be added to urban soil to improve soil ecosystem functioning. One major concern about the use of these amendments is their high nitrogen and phosphorous content, which could facilitate invasion of restored communities. It is unclear if organic amendments improve restoration success over time. To assess long-term impacts of four organic soil amendments on an unmanaged restoration project, we re-surveyed a restored site at the Metropolitan Water Reclamation District of Greater Chicago East Calumet wastewater treatment and biosolids processing facility in Calumet, Illinois ten years after establishment. The site was divided into twenty 18m<sup>2</sup> randomized plots with four replicates of four treatments + control. We collected aboveground biomass from two 0.25m<sup>2</sup> sub-plots for each plot in September 2019. Preliminary analyses show unamended control plots have the highest species diversity compared to all biosolids treatments. There were no differences in species richness or productivity between treatments. We plan to test whether type or organic amendment impacted relative abundance and productivity of invasive species, namely phragmites (*Phragmites australis*). This work suggests although organic soil amendments improve soil health, they may reduce plant diversity outcomes in the long-run.

## **WEDNESDAY AFTERNOON CONCURRENT SESSIONS**

### **Workshop: Bringing Divergent Views Together with Open Space Meetings**

Instructors: April Rust and Brian Stenquist, Minnesota Department of Natural Resources

Open Space meetings are discussions where the participants create and manage their own agenda of concurrent working sessions around a central theme of strategic importance. This special session will introduce Open Space meetings by inviting attendees to experience a short virtual Open Space meeting first-hand. We will also share how the use of Open Space worked in Minnesota and describe the set of Open Space meetings hosted by the Minnesota DNR and the Minnesota Aquatic Invasive Species Advisory Committee in 2019. To gain deeper understanding of natural resource issues important to Minnesotans, we hosted three public events around the theme: What can we do to more effectively address the issues of promoting access to Minnesota's Lakes and Rivers, providing excellent recreational fishing, and stopping the spread of aquatic invasive species? Using an Open Space format, a combined 186 attendees set the meeting agendas, led group discussions, exchanged different perspectives, and recorded notes. Active conversations among local residents, lake associations, anglers, local governments, and other interested participants explored how communities can work together better to address shared concerns. Following the meetings, Both the DNR and the AIS Advisory Committee committed to reviewing the notes from each session and diving into the lessons learned.

## **Why the Words We Use Matter**

### **Disconnects between Communicated Impact and Ecological Impact of Biological Invasions**

*Kali Mattingly\*, Tara Pelletier, Jessie Lanterman, Danielle Frevola, Benjamin Stucke, Kaitlin Kinney, Ross Schwartz, Drew Spacht, Graham Dixon, Stephen Hovick; The Ohio State University*

Although scientists strive to accurately communicate their research, disconnects can arise between results and rhetoric. Some have regarded invasion scientists as particularly prone to using value-laden language incommensurate with the scientific facts or results. At the center of this discussion is use of the word "invasive." Many policy-makers and members of the public, as well as some scientists, interpret "invasive" as implying economic or environmental impacts. However, no synthesis has gauged how scientists use "invasive" in practice. We used a dataset including 202 scientific articles and 1,003 effect sizes to address how authors used 10 near-synonyms (words for which usage is similar but not completely overlapping) of the negative-value word "invasive." We asked whether study findings regarding invasion impacts (effect sizes) or other factors predicted scientists' language use. Use of negative-value words like "invasive" was not associated with study findings but instead with contextual factors. For example, plant and invertebrate biologists used more negative language to describe non-natives than those studying vertebrates. Authors also tended to use more negative language in recently published papers compared to older studies. Although some have called for impact to be considered a necessary component of the definition of "invasive," scientists use negatively valued words like "invasive," "weed," and "pest," regardless of measured impacts. Such use may affect how the public perceives scientific findings.

### **What's In a Name? Thoughtful Nomenclature Makes a Difference**

*Angela Gupta\*<sup>1</sup>, Megan Weber<sup>1</sup>, Doug Jensen<sup>2</sup>; <sup>1</sup> University of Minnesota Extension; <sup>2</sup> University of Minnesota Sea Grant Program*

The University of Minnesota (UMN) Extension's Invasive Species Community of Practice (IS CoP) believes in the adoption and use of appropriate, acceptable names for new invasive species reflective of our values for diversity and engagement. As outcomes of this effort, IS CoP developed guiding principles to inform selecting primary common names for new non-native species. Additional processes were developed to apply these new principles to Extension programs. What's in a name? A lot. In 2014, Minnesota legislators passed a bill that included a name change for state agencies from "Asian carp" to "invasive carp", in response to concerns raised by the Asian-American community. Yet, many other, potentially invasive species with similar place-based names exist and are emerging in Minnesota without discussion like crazy worms, Manchu tubergourd, Siberian squill, etc. To help inform a process for thoughtful development of appropriate common names, IS CoP reached out to two invasive species research centers and Extension's Foreign Born Affinity Group at UMN for feedback and review. Their feedback drastically changed our approach and increased our sensitivity to this issue. This presentation will review key discussion points and the decisions, revisions and procedural practices that resulted. Our first test of this process resulted in naming and approving use of the common name red hailstone for *Thladiantha dubia*. Outcomes are that red hailstone is now used by EDDMapS, iNaturalist, MN Wildflowers and eventually USDA Plants Database. This suggests the UMN IS CoP can offer thoughtful leadership concerning nomenclature and influence state and national platforms."

## **Outreach in a Digital World**

*Rebekah Wallace\*, Chuck Barger, Rachel Carroll; University of Georgia*

Many outreach strategies rely heavily on traditional methods, such as flyers, booklets, in-person presentations, etc. As social media and the internet are accessible to more people, programs and outreach messages can reach further than ever before. However, messages and strategies have to be modified for these formats. Guidance on communication methods, strategies, and more come from different sources and may not be tailored to scientific outreach and its needs. Webinars, newsletters, websites, social media, and other digital resources can reach your traditional audience and people you would not have been able to reach otherwise, but may require additional skill sets and a different approach.

## **Seeing, Hearing and Feeling: The Clean Drain Dry Partnership Message**

*Dane Huinker; Wildlife Forever*

Prevention is recognized as the best defense to protect our resources. Knowing what to do to halt the spread must become part of every outdoor activity. From fishing to hunting to hiking and biking, a few smart steps including widespread basic awareness can have lasting benefits. Since 2006, Clean Drain Dry, the national public awareness and education program, has reached over 2 Billion contacts. That's roughly 5.8 impressions per person living in the USA. Each year, through consistent messaging and targeted outreach marketing, we're influencing people to take action at the boat ramp, on the trail, and in the field. We will showcase how pooling funds, collaboration, and consistent prevention marketing can spawn innovation, reduce duplication, and provide leadership to address this national invasion. We work in partnership with resource managers and community stakeholders who share our vision and believe in the value of investing in education and public awareness. Throughout the nation, Clean Drain Dry can be SEEN in storefront windows, bait shops, on highway billboards, and in magazines and local newspapers. On television and radio, at community meetings, and from watercraft inspectors, the message is HEARD loud and clear. At county fairs, local events, and at the boat ramp, volunteers and inspectors distribute educational products and handouts that could be FELT. These three elements-See, Hear, and Touch- are the foundations for changing public behavior. When we connect with people who have a passion for the outdoors, compliance with Aquatic Invasive Species (AIS) laws and other terrestrial guidelines increase, and the rate of spread slows.

## **2:50PM PlayCleanGo®: Upper Midwest Partnerships and How Your Organization Can Participate**

*Krista Lutzke; North American Invasive Species Management Association*

PlayCleanGo® has grown from its origins at the Minnesota Department of Natural Resources with major support from USDA Forest Service and USDA APHIS to be the leading, universal prevention and outreach campaign in North America. Through partnerships with other national prevention brands, local to national environmental and recreational organizations, clear messaging and community-based social outreach, PlayCleanGo raises awareness of how and why thousands of invasive species are spread every year by recreationists. The North American Invasive Species Management Association (NAISMA) is now the owner of the patented PlayCleanGo brand and is the lead coordinating agency facilitating partnerships from local to national and international agencies and organizations in the Upper Midwest and throughout North America. Learn in this presentation how you can get access and integrate the PlayCleanGo brand, messaging, and turn-key prevention and outreach tools with your own local messaging and strategy.

## **Boater Behavior: From Theory to Practice**

### **Lake Public Access Observations for Aquatic Invasive Species Prevention Behaviors**

*Tony Brough<sup>\*1</sup>, Carolyn Dindorf<sup>2</sup>, Katie Farber<sup>2</sup>; <sup>1</sup> Hennepin County; <sup>2</sup> Fortin Consulting, Inc.*

This project conducted observation research of aquatic invasive species (AIS) prevention behavior for those using public lake accesses in Hennepin County. The observations summarized in this report were made incognito and when access inspectors were not present. Observations were conducted at four Hennepin County public accesses with a variety of signage types, equipment, and inspector frequency. Accesses included Lake Minnetonka-Spring Park (Spring Park), Lake Minnetonka-Surfside (Surfside), Long Lake, and Weaver Lake. This report summarizes three years of observations, which include observations at Spring Park and Long Lake accesses from 2017-2019, and observations at Surfside and Weaver Lake accesses in 2017 and 2019. The four accesses have various levels of AIS prevention redesign and inspector presence. Redesign occurred at the accesses in different years. Spring Park access has a programmable electronic message board, pavement markings for traffic flow, CD3 self-serve waterless cleaning stations, and a high frequency of Minnesota Department of Natural Resources (MN DNR) inspector presence. Long Lake access has updated AIS prevention prompt signs, pavement markings, a CD3 self-serve waterless cleaning station, and an infrequent MN DNR inspector presence. Weaver Lake has updated AIS prevention prompt signs, pavement markings, a CD3 outpost self-serve cleaning station, and does not have an inspector presence. Surfside access has standard MN DNR signage and does not have an inspector presence. This talk will discuss some of the findings from the 109 observation dates which included 1,156 non-commercial boats.

### **A Comparison of Watercraft Decontamination Methods: Invasive Species Removal, Boater Outreach, and Cost**

*Maria Bleitz<sup>\*1</sup>, Jo Latimore<sup>1</sup>, Kevin Walters<sup>2</sup>; <sup>1</sup> Michigan State University; <sup>2</sup> Michigan Department of Environment, Great Lakes, and Energy*

The secondary spread of Aquatic Invasive Species (AIS) via trailered watercraft to inland lakes and reservoirs is an issue that negatively affects native species and costs billions of dollars in the Great Lakes region every year. Preventative efforts against AIS have focused on reducing overland spread by encouraging boaters to remove invasive organisms from their watercraft, trailers, and gear before launching in another lake. Local communities have installed boat wash stations at launch sites that use heated pressurized water to remove invasive animals and plant fragments. Recently, several local communities including Higgins Lake have purchased waterless boat cleaning stations such as CD3 units that use compressed air, vacuums, and hand tools. Few studies have compared these two cleaning approaches, and none have in the context of Michigan's regulations. We conducted a review of published literature and unpublished data with the goals of assessing the effectiveness of both boat-cleaning methods in terms of AIS decontamination effectiveness, boater/angler outreach effectiveness, and cost effectiveness. The review includes a synthesis of 1) unpublished data collected by the CD3 units at Higgins Lake, survey data collected by the Michigan State University Mobile Boat Wash program, data from various local boat operations, and 2) reports compiled by CD3, white papers, and primary literature of various decontamination methods. The findings will be presented as a resource for lake managers considering investing in boat cleaning equipment or programs at their own lakes.

### **Online Boater Led Check-In/Check-Out Alternative to In-Person Inspections: A COVID-19 Response Pilot**

*Mark Apfelbacher<sup>\*</sup> and Edgar Rudberg; CD3, General Benefit Corporation*

Due to the high cost of high pressure, heated water decontamination, reducing the spread of aquatic invasive species (AIS) often relies upon the adoption of best management practices at the individual level. This is especially needed during a pandemic. This presentation will outline a pilot project in Minnesota in adopting a

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

### **AIS Prevention During COVID-19**

*Erin McFarlane\*<sup>1</sup>, Jeanne Scherer<sup>2</sup>; <sup>1</sup> University of Wisconsin Extension Lakes; <sup>2</sup> Wisconsin Department of Natural Resources & University of Wisconsin - Madison Extension*

Education, monitoring, control, watercraft inspection, and Wisconsin Department of Natural Resources grants to support these activities are all vital parts of Wisconsin's Aquatic Invasive Species (AIS) program. With the arrival of COVID-19 came some challenging issues that required important discussions with our AIS partners and staff. Many of our dedicated lake volunteers and grantees fall under the category of those most vulnerable to the virus, and program adjustments had to be made in an effort to keep our volunteers and the public safe. Join us to learn how we adapted our statewide outreach campaigns, watercraft inspections, and other core parts of our AIS Prevention program to meet the needs of our citizens and our state. We will share survey results that examine how people adapted their direct programming, as well as examples of outreach materials developed for use during the pandemic.

## **Using Herbicides to Improve Management of Invasive Plants, Part 1**

### **Introduction to Rinskor™: A New Molecule for Increased Control of Broadleaf Weeds and Brush**

*Scott Flynn; Corteva Agriscience*

TerraVue is a new herbicide developed by Corteva Agriscience™, for control of broadleaf weeds, including invasive and noxious weeds, and certain woody plants. TerraVue represents an innovative new tool that is a non-ester, non 2,4-D containing, low odor, low use rate formulation that provides post emergence and pre-emergence residual control of susceptible broadleaf plants and seedlings and some woody plants. TerraVue is now federally registered with USEPA and registered in many states across the US. It will provide control of all species known to be controlled by Milestone® herbicide plus many additional species and offers flexibly in application (ground, aerial, broadcast, or spot treatment). A key component of TerraVue is Rinskor™ active, a novel new active ingredient never before used in rangeland and pastures and is an EPA Reduced Risk Pesticide, as is Milestone. In trials over multiple years across the United States, TerraVue provided excellent control of weeds such as yellow starthistle (*Centaurea solstitialis*), Canada thistle (*Cirsium arvense*), musk thistle (*Carduus nutans*), wild carrot (*Daucus carota*), Purple loosestrife (*Lythrum salicaria*), silverleaf nightshade (*Solanum elaeagnifolium*), squarrose knapweed (*Centaurea squarrosa*), spotted knapweed (*Centaurea maculosa*), poison hemlock (*Conium maculatum*), woolly croton (*Croton capitatus*), annual marshelder (*Iva annua*), common broomweed (*Gutierrezia dracunculoides*), common caraway (*Carum carvi*), and many more. Based on these efficacy data, it is anticipated that TerraVue will be a useful tool in the management of noxious, invasive and other weeds in various sites.

### **TerraVue - A New Standard for Broadleaf Weed Control: Use Sites and Effectiveness**

*Jerome Otto\* and Karissa Floerchinger\*; Corteva Agriscience*

## Comparison of Effectiveness of TerraVue to Standards on Roadsides in Wisconsin

Mark Renz; University of Wisconsin - Madison

Roadside rights-of-way (ROW) provide important ecosystem functions, but they also are dispersal corridors for invasive plants. While ROW land managers actively control invasive plant infestations, limited information on effective control techniques often prevents management. As new products for invasive plant control such as TerraVue (aminopyralid + florpyrauxifen) become available, information on efficacy compared to standard treatments is needed. We conducted experiments at four locations in Wisconsin to evaluate the effectiveness of TerraVue compared to other control methods on wild parsnip (*Pastinaca sativa* (L.)), teasel (*Dipsacus* sp.), and wild chervil (*Anthriscus sylvestris*). Nine herbicide-based and five mechanical management methods for controlling these species were evaluated. Herbicides broadcasted in May 2019 included Milestone (7 fl oz/A), Opensight (2 oz/A), Method (8 fl oz/A), TerraVue (2.85 oz/A), Escort (0.5 oz/A), and 2,4-D + dicamba (16 + 8 fl oz/A). Two treatments were also applied as individual plant treatments (IPT), including 2,4-D (0.5% v/v) + dicamba (0.5% v/v), and glyphosate (1% v/v). Mowing and individual plant removal treatments were also included as well as an untreated control. All treatments were replicated three times. Across all species, TerraVue provided > 90% control of teasel, >95% control wild chervil, and > 95% control of wild parsnip in the year of treatment. While IPT treatments and mowing did prevent the development of viable seeds, control using these methods was typically two to threefold worse than TerraVue through fall of the treatment year. While other products provided similar control during this timeframe (Opensight, Escort, Method for wild parsnip and teasel; Method for wild chervil) results demonstrate that TerraVue is an effective alternative to these products and should be considered as an option for invasive plant management programs on roadsides.

## Desirable Forb Tolerance to Applications of Rinskor®-containing Herbicides (Duracor™ & TerraVue™) in Rangeland, Pastures and Non-Crop Sites

Chad Cummings; Corteva Agriscience

Native desirable forbs are a vital part of natural ecosystems around the world. These forb species are necessary in many plant communities for multiple trophic level obligate species. Forb response to aminopyralid has been investigated in the past. The current studies investigated forb response to TerraVue™ herbicide (Rinskor™ + Aminopyralid), a new land management herbicide labeled for control of annual and perennial broadleaf weeds and enhanced control of certain woody brush species. Studies initiated in 2018 and followed in 2019 indicate that 92% of the forb populations were tolerant to moderately tolerant at 1 YAT, similar in visual cover to the untreated check at many trial sites. Preliminary data demonstrate that key species including golden alexanders (*Zizia* spp.), milkweeds (*Asclepias* spp.), and goldenrods (*Solidago* spp.) remained in the plant community the year following applications of TerraVue herbicide. Current research trials indicated several species likely will be decreased in the plant community following TerraVue herbicide application including: sunflowers (*Helianthus* spp.), Scurfpea (*Psoralea* spp.), and wormwood (*Artemisia* spp.), particularly when applied within the growing season. Based on previously reported efficacy data, TerraVue will be a useful tool in the management of weeds and some enhanced brush control in various use sites. In addition, TerraVue herbicide will have minimal long-term impact on many native forb populations, similar to reported results for Milestone herbicide.

## **Invasives & Restoration 4:**

### **Lessons Learned - Planning & Improving Future Restorations**

#### **The Effects of Dams on Minnesota Fish Communities**

*Amy Childers\* and Luther Aadland; Minnesota Department of Natural Resources*

Freshwater animal extinction rates are about 5 times that of terrestrial rates. This alarming trend is linked to habitat degradation and fragmentation. Dams have a variety of detrimental effects including the effects on fish migrations and the decline of migratory species that have been acknowledged for over 300 years. To address the impact of dams on native fish communities of Minnesota, the presence/absence of fish species in the upstream versus downstream watersheds of 32 dams throughout Minnesota was analyzed. Georeferenced fish records from various reliable sources were used to tabulate the presence and absence of fish above and below the barriers. On average, species richness declined by 43% for the 20 complete barriers and declined by 37% for all 32 barriers. Sensitive, stream-dependent, and imperiled species were most likely to be absent upstream of barriers. Habitat generalists, tolerant, lake-oriented, headwater, and widely stocked species were least likely to be absent upstream of barriers. Can or will fish return if the barrier is removed? Of the 32 dams analyzed, 13 have been removed or modified for fish passage. In all cases, fish species did return, even with only a few years of data. An average of 68% of the absent species returned to the upstream watershed. This data verifies that efforts to remove or modify barriers on naturally connected stream networks will greatly benefit fish communities. Moreover, reconnecting rivers has been shown to increase the diversity and resilience of native species while decreasing the prevalence of invasive species.

#### **Reed Canarygrass: Implications for Control of an Invasive Species When It Is Native**

*Neil Anderson\*<sup>1</sup>, Andrzej Noyszewski<sup>1</sup>, Alan Smith<sup>1</sup>, Diana Dalbotten<sup>1</sup>, Emi Ito<sup>1</sup>, Anne Timm<sup>2, 1</sup> University of Minnesota;*

*<sup>2</sup> USDA - Forest Service*

Minnesota has the highest concentration of reed canarygrass (*Phalaris arundinacea*) in North America, which have been assumed to be exotic and targeted for control. It is classified by the DNR as a threat, although it does not have regulatory status. Immense public and private funding has been used to mitigate its spread and effect limited control. Its varied history statewide includes native and unplowed stands, widespread multi-purpose use by Native Americans, forage seed production, spread across the Midwest during the Dust Bowl era, cultivation as an ornamental, use for restoration/reclamation and biofuel. Its rampant spread across the state is due to a variety of historic and modern-day factors. Recent genetic evidence from single nucleotide polymorphism (SNP) marker-based research showed that all Minnesota riparian, forage and wet meadow populations were native and distinct from Czech populations. Sampled populations were from six major rivers (Des Moines, Minnesota, Mississippi, Red, Roseau, St. Croix) as well as wet meadows, unplowed fields and forage cultivars; additional herbaria samples indicated this native status. We will share these findings along with data from ongoing sample collections along Minnesota highways, lakes and parks statewide. The focus of this talk will concentrate on the implications that native, yet invasive, reed canarygrass have for public and private land managers operating throughout Minnesota (MnDOT, DNR, Tribal, Nature Conservancy, etc.). We will delineate potential management options for this native invasive species, which will affect future funding for its control as well as options for preserving native stands throughout the state.



## **Diversity Makes the World Go Round: Resisting Invasion by Design**

*Megan Benage; Minnesota Department of Natural Resources*

Prairie reconstruction has changed over the years. We've moved from planting solid stands of switchgrass to the push for dense nesting cover, and now as we learn more, we adapt again to plant floristically diverse prairies that benefit a wider variety of species and as it turns out can resist invasion. The MN DNR is shifting our approach to prairie reconstruction to try to better mimic native prairies to maximize wildlife benefits, function, and long-term resilience. This talk will cover the lessons learned from a prairie landscape that was whole that can be applied in our seed mix design today. We've learned identifying your target community and goals, site considerations, species selection, and seeding rates are key components to successful seed mix design. I'll walk you through those steps and hopefully arm you with the tools to feel more confident in building a kick-butt prairie (Canada thistle, optional).

## **Reducing Risk of Exotic Plant Introduction in Native Prairie Seed Provenancing**

*Jennifer Larson<sup>\*1</sup>, Diane Larson<sup>1</sup>, Rob Venette<sup>2</sup>; <sup>1</sup> U.S. Geological Survey; <sup>2</sup> USDA - Forest Service & University of Minnesota*

Large-scale prairie restoration and reconstruction continues to increase in occurrence across the Great Plains region, with the intent of preserving at-risk species and connecting fragmented landscapes. With this increase comes a greater need for commercial seed supply sources to meet the growing demand for native prairie seed. Many of these restoration projects require species translocations, mainly as seed, from one part of a species' range to another. While practitioners would prefer (and often are lawfully required) to source seed locally, supply and diversity of seed for large scale projects is limited. Practitioners are then left with the choice to source seeds from farther away than desired, not only with genetic concerns of outbreeding depression or maladaptation, but with increasing likelihood that novel, exotic weed species could inadvertently arrive in their native seed mix. To address this issue, we created georeferenced databases of weedy, exotic plant species distributions and commercial native prairie seed producers in and surrounding the upper Midwest level II temperate prairie ecoregion. We then use these georeferenced databases to provide a spatially explicit framework for assessing the amount of risk of invasive species contamination as distance between reconstruction site and seed producer increases. In balancing the benefit of maximizing the number of seed supply sources while minimizing the risk of introducing novel exotic weeds, we provide an empirical framework that can guide provenancing choices of restoration practitioners.

## **Improving Ecological Restoration to Curb Biotic Invasion**

*Diane Larson<sup>\*1</sup>, Qinfeng Guo<sup>2</sup>, Dale Brockway<sup>2</sup>, Deli Wang<sup>3</sup>, Hai Ren<sup>4</sup>; <sup>1</sup> U.S. Geological Survey; <sup>2</sup> USDA - Forest Service; <sup>3</sup> Northeast Normal University; <sup>4</sup> Chinese Academy of Sciences*

At some level, ecological restoration must always grapple with unwanted invasive species. Our aim in this talk is to describe ways in which we can make invasive species reduction an explicit part of our restoration plan and implementation. We address five key aspects of ecological restoration. First, we encourage a broad view of site assessment, in which alpha, beta and gamma diversities with respect to the surrounding landscape are considered. An estimation of the likely invasive seedbank as well as locations of potential and existing buffer zones around the core restoration area are important aspects of this assessment. Resistance to invasive species and ecosystem resilience after disturbance and invasive species removal should occupy a primary place in the restoration goals established for the site, while keeping in mind accommodation to climate change and desired trophic level composition. Tradeoffs resulting from budget limitations are important to recognize during goal-setting exercises. Careful species selection can maximize the opportunities for limiting similarity, priority effects, space occupancy, and even novel weapons, for fighting invading species. Soil conditioning is often given short

shift, but mycorrhizal fungi and nodulating bacteria are key biotic components of healthy plant communities that can better withstand and repel invasive plant species. Finally, monitoring: Just do it! Without follow-up monitoring, incipient invasions and problem areas that are ripe for invasion will be missed and corrective action that could have prevented invasion will not occur.

## THURSDAY EARLY MORNING CONCURRENT SESSIONS

### **Phragmites Symposium 1: Current Approaches to Management**

#### **Great Lakes *Phragmites* Collaborative: Working Towards a Common Agenda**

Erika Jensen<sup>\*1</sup>, Samantha Tank<sup>1</sup>, Patrick Canniff<sup>1</sup>, Kurt Kowalski<sup>2</sup>; <sup>1</sup> Great Lakes Commission; <sup>2</sup> U.S. Geological Survey

Non-native *Phragmites australis* is a highly invasive wetland grass that is widespread across North America. In the Great Lakes Basin, *Phragmites* negatively impacts fish and wildlife habitat and impedes recreation and public access. Land managers continue to devote a significant amount of time and money to manage it, but landscape-scale coordination among managers is difficult. The Great Lakes *Phragmites* Collaborative (GLPC) was formed to improve communication and collaboration between states, localities, and federal managers. Since its formation in 2011, the GLPC has applied a collective impact approach (e.g., develop a common agenda) to organize and empower *Phragmites*-related activity throughout the basin. The GLPC manages and maintains a website (<http://greatlakesphragmites.net/>) that acts as the central resource hub containing vital information about *Phragmites* ecology and identification, management guidance, dozens of newsletters and blog posts, and a local invasive species management organization mapping tool. In addition, GLPC runs a successful research- and management-focused webinar series, hosts a 700-member listserv, and supports the growth of the *Phragmites* Adaptive Management Framework (<http://www.greatlakesphragmites.net/pamf/>). Working from a common agenda to advance effective *Phragmites* management, the GLPC identifies stakeholder needs and goals, develops dynamic resources to meet those needs, facilitates communication and aligns efforts among researchers and managers, and promotes multi-year management and restoration planning.

#### **Non-native *Phragmites* (*Phragmites australis* subsp. *australis*) Management in Coastal Southwestern Lake Superior**

Travis Bartnick; Great Lakes Indian Fish & Wildlife Commission

The Great Lakes Indian Fish & Wildlife Commission (GLIFWC) began documenting occurrences of native American common reed (*Phragmites australis* subsp. *americanus*) and non-native European common reed in northwestern Wisconsin in 1999. GLIFWC subsequently prioritized non-native *Phragmites* for monitoring and control because of the detrimental impacts this species could have on Ojibwe treaty resources in the region. In 2013, GLIFWC began documenting the increasing number of non-native *Phragmites* sites around the Chequamegon Bay area of southwestern Lake Superior. Nearly all of the observed sites were found in close proximity to wastewater treatment plants that had been using non-native *Phragmites* in their sludge dewatering process. In 2013, GLIFWC began implementing herbicide treatment of non-native *Phragmites* sites around Chequamegon Bay. GLIFWC also initiated surveys for non-native *Phragmites* in the St. Louis River Estuary in 2014, and began herbicide treatments of these sites in 2015. Follow-up monitoring, additional surveys, and control work have been conducted ever since. This presentation will provide an overview of the management approach, collaborative work, and the current status of non-native *Phragmites* populations in this region.

## **Coordinated Response to Invasive *Phragmites* in Minnesota**

*Julia Bohnen\*, Daniel Larkin, Susan Galatowitsch; University of Minnesota*

The distribution of the European strain of common reed (*Phragmites australis* (Cav.) Trin. Ed Steud.) in Minnesota is still relatively limited, but quickly expanding. Through our work from 2017 to 2019, we mapped and verified approximately 500 stands of invasive *Phragmites*. Most of these are small, less than a half-acre in area, but are likely to expand and spread to new locations without proactive management. For example, germination and viability tests showed that 61% of sampled populations were capable of producing viable seed, primarily in the southern two-thirds of the state. Using these findings, we developed a statewide management plan to address *Phragmites* in different regions of the state, which vary greatly in the timescale and extent of invasion. With funding support from and in partnership with the Minnesota Department of Natural Resources, we will continue to provide research, outreach, and technical support to work on reversing the spread of *Phragmites* in Minnesota. One area of focus will be to work with local entities to facilitate control efforts, with an emphasis on areas with few, scattered populations. Monitoring and recordkeeping protocols will be implemented in order to document treatment efficacy. Another increased area of focus will be working with wastewater treatment facilities that use invasive *Phragmites* in "reed beds" to dewater biosolids. We will work with wastewater facility operators to identify and implement practices that minimize spread of *Phragmites* from their facilities and support the eventual transition of facilities toward dewatering approaches that are not reliant on invasive *Phragmites*.

## **Semi-Automated Identification and Monitoring of *Phragmites australis* Using Drones and Satellites**

*Connor Anderson\*, Daniel Heins, Keith Pelletier, Joseph Knight; University of Minnesota*

Knowing the locations of invasive plant infestations is critical for their control. In situ surveying methods are useful for tracking small-scale invasions; however, these methods face challenges when scaling to larger or more dispersed areas. Similarly, field monitoring through citizen science is helpful, but monitoring of large areas may require years and is dependent on individual volunteers. Additionally, infestations near population centers have the potential to be detected more readily compared to remote locations due to accessibility. This may lead to populations in remote locations going unchecked. Remote sensing offers the potential for the semi-automated identification of invasive plant infestations at a landscape scale with less time and cost. To this end, the Remote Sensing and Geospatial Analysis Lab (RSGAL) at the University of Minnesota Twin Cities has been funded by the Minnesota Invasive Terrestrial Plants and Pests Center (MITPPC) to develop and test remote sensing methods for identifying and monitoring invasive *Phragmites australis* populations across the state of Minnesota. Our study focuses on two remote sensing data types: 1) Spaceborne satellite imagery for identification at large geographic areas (> ~1 mi<sup>2</sup>), and 2) drone imagery for rapid detection and monitoring at smaller geospatial scales (< ~200 acres). This presentation will describe the application of spaceborne satellite platforms and drones for *Phragmites* identification. Preliminary results will be presented that demonstrate a semi-automated identification of *Phragmites* from drone and satellite imagery.

## **Mapping Invasive *Phragmites* Treatment Outcomes with UAS Imagery**

*Charlotte Weinstein\*, Colin Brooks, Andrew Poley, Amanda Grimm, Nicholas Marion, Dana Hansen; Michigan Tech Research Institute*

The non-native variety of common reed (*Phragmites australis*) has been a nuisance in the Great Lakes region since the mid-20th century, during which it has negatively impacted the quality and function of wetland ecosystems. Adequate monitoring and evaluation plans are needed to support the success of *Phragmites* treatment and restoration programs, yet they can be difficult to implement due to certain site characteristics and resource constraints. Unmanned aerial systems (UAS) have been increasing in capability in recent years, and

are becoming more practical platforms for providing the type of relatively low-cost, high-resolution remote sensing data that can be useful for monitoring wetland sites. In this study, we tested the feasibility of the use of UAS for *Phragmites* treatment monitoring by collecting imagery and vegetation data at 20 sites in the Great Lakes region. This imagery was classified using a nearest neighbor algorithm to create vegetation maps of each site. The resulting classifications were validated and assessed through visual interpretation at several randomly placed points throughout each image. The overall mean accuracy across each of the study sites was 91.73%, and overall median accuracy was 92.62%, indicating that UAS imagery can be useful as a safe, relatively time- and cost-efficient method for monitoring the impacts of *Phragmites* treatment. A treatment site's location, canopy cover, and size are all important considerations to determine whether use of UAS is appropriate.

## **Organisms in Trade: Fostering Responsible Businesses**

### **Recent Trade-Pathway Invasive Species Prevention Efforts in Minnesota**

*Chelsey Blanke; Minnesota Department of Natural Resources*

The Minnesota Department of Natural Resources (DNR) Invasive Species Program has been working to improve trade-pathway invasive species prevention. Global trade drives invasive species introductions to Minnesota and the United States. The horticulture, pet, food, bait, and classroom and laboratory biological supply trades are some of the known pathways for invasive species. In recent years, DNR staff has been working to assess invasive species risks associated with each of these trades and develop relationships with business owners and industry. An assessment of pathways revealed that about 2/3 of Minnesota prohibited invasive species, those that are illegal to possess and sell, have been documented in the trades listed above (42 species). Additionally, 3/4 of Minnesota regulated invasive species have been documented in these trades (15 species). In collaboration with the University of Minnesota Sea Grant Program, DNR staff developed and distributed guidance for reducing risk of invasive species introduction through trade pathways. We also surveyed Minnesota businesses about their concerns, knowledge and business practices related to invasive species prevention and management. Ongoing work aims to identify and reduce trade-pathway invasive species risks through the development of partnerships and breaking down barriers to invasive species prevention best practices.

### **Preventing Aquatic Invasive Species Introductions through Retailer Engagement**

*Paige Filice\*<sup>1</sup>, Jo Latimore<sup>2</sup>; <sup>1</sup> Michigan State University Extension; <sup>2</sup> Michigan State University*

Animal and plant species available in the aquarium and water garden trade pose a significant ecological and economical threat if they are released into the wild. To address this in Michigan we created the organisms-in-trade program [Reduce Invasive Pet and Plant Escapes (RIPPLE)] in 2015. Over 120 organizations are RIPPLE partners including pet and garden retailers, hobbyist clubs, nature centers, zoos and school districts. We engage our partners through trainings, publications and retailer visits. Our communication focuses on aquatic invasive species identification and handling and disposal techniques. Program partners also receive RIPPLE outreach kits containing print materials for display and distribution. To ensure RIPPLE meets the needs of our target audience, we surveyed all independently owned pet and garden retailers in Michigan that sell aquatic organisms or provide services to aquatic hobbyists. The survey improved our understanding of retailers' knowledge of aquatic invasive species, current behavior, and attitudes regarding their responsibility for prevention. Results indicate that while many retailers believe that aquariums and water gardens pose an invasive species risk, some do not believe they are responsible for educating their customers about invasive species or how to prevent introductions. In addition, only half of surveyed retailers in Michigan accept unwanted plants or animals from the public. Utilizing our survey results we are enhancing the RIPPLE program and designing additional outreach products to empower our program partners to prevent the introduction of organisms in trade into the wild.

## **"Don't Let It Loose" - Building an Outreach Campaign to Prevent Aquatic Invasive Species**

*Sara Cowell\*<sup>1</sup>, Stephanie Sardelis<sup>1</sup>, Julie Carpentier<sup>1</sup>, Jeff Brinsmead<sup>2</sup>, Laureen Janusz<sup>3</sup>, Martina Beck<sup>4, 1</sup>  
Fisheries and Oceans Canada; <sup>2</sup> Ontario Ministry of Natural Resources and Forestry; <sup>3</sup> Government of Manitoba; <sup>4</sup>  
Government of British Columbia*

Preventing the introduction and spread of aquatic invasive species (AIS) is the most effective and cost-efficient strategy to limit negative impacts on our biodiversity, economy, and society. The general public plays an important role in preventing AIS from harming our environment, as many organisms are spread along human-mediated pathways. People may release aquatic animals and plants into nature for a variety of reasons, from setting live food free and satisfying cultural release practices, to dumping live bait and disposing of aquarium pets, among others. Many people undertaking such activities may not understand the damage they are facilitating and may be unaware of the illegality of their actions. To staunch the release of non-native organisms into waterbodies, social norms need to be established through education and outreach to encourage alternative sustainable behaviours. "Don't Let It Loose" is a versatile message that can be used to increase public awareness of AIS and encourage citizen involvement in protecting the environment. Canada's federal department of Fisheries and Oceans Canada (DFO), in collaboration with its provincial and territorial government partners, has developed a new "Don't Let It Loose" brand to provide partners with tools that can be implemented consistently both within Canada and internationally for maximum uptake and impact. The new brand includes a clear vision, four central message layers, logotypes, an implementation toolkit with guidance on consistent implementation, and a variety of print and promotional materials.

## **Be PlantWise – Making a Difference to Reduce the Spread of Horticulturally Invasive Plants in British Columbia**

*Danielle Toperczer; Invasive Species Council of BC*

Are you PlantWise? The horticulture industry is a key pathway for the introduction and spread of invasive plants into gardens, fields, roadways, vineyards, and natural areas across British Columbia. PlantWise is a province-wide initiative developed by the Invasive Species Council of BC (ISCBC) in partnership with the horticultural industry, and is rooted in behaviour change research. The goal of the program is to support gardeners, landscapers, farmers, nursery growers and plant retailers to choose only responsible non-invasive alternatives or native plants instead of invasive ones. PlantWise includes "Grow Me Instead" resources that highlight non-invasive alternatives to commonly requested invasive species such as invasive Butterfly bush and baby's breath, and commitment pledges for both the consumer and retailer. The program also features presentations to industry, in-store resources and signage, and a recognition program for nurseries and retailers who commit to being PlantWise. This presentation will review the collaborative development process of the program, explore its successes and challenges and highlight next steps in its evolution.

## **Using Herbicides to Improve Management of Invasive Plants, Part 2**

### **Protecting Valuable Native Plants and Reducing Herbicide Use while Controlling Non-native Invasive Plants**

*John Lampe\*<sup>1</sup>, Taylor Bokman\*<sup>2</sup>; <sup>1</sup> Green Shoots, LLC; <sup>2</sup> Minnesota Native Landscapes*

Native, herbaceous plants can live for up to 40 years. Therefore off-target spray from herbicide applications is especially concerning because of potential environmental and economic impacts it can cause to the longevity of the native plants. Conventional spray systems use high-pressure which produces greater quantities of tiny spray drops.

These tiny spray drops can easily move off-target, carried by the wind and even air currents created by the act of spraying. Their small size makes these droplets invisible to the naked eye and makes it difficult to gauge potential off-target damage. In this talk, we explore ways to make herbicide applications more precise. Two methods are discussed: low pressure spray and foam herbicide. We explore examples of precision application in the native plant production industry.

### **Is there a Magic Bullet? Greenhouse Screening of Herbicides on Bohemian Knotweed (*Fallopia x bohemica*)**

*Roger Becker\*, Alan Smith, Neil Anderson, Jeanie Katovich, Mary Marek-Spartz, Ryan Mentz; University of Minnesota*

Control of knotweeds with herbicides has been inconsistent, costly, requires follow-up treatments, and may have significant environmental impacts. It is difficult to perform comparative studies on invasive knotweed control with herbicides in the field for several reasons. Have we missed finding the "magic bullet" for knotweed control? To find out we conducted exploratory herbicide efficacy and optimization studies in the greenhouse with perennated potted juvenile clones of Bohemian knotweed collected from a single source screening 22 herbicide active ingredients and five modes of action with titrations of several key herbicides. Efficiencies of greenhouse trials allows screening many treatments and rate titrations under the same conditions to better define relative activity on knotweeds within chemistries and modes of action. Inconsistent control has been reported with aminopyralid and aminocyclopyrachlor but both performed very well in this initial trial. As anticipated, imazapyr provided the highest unit activity and consistency of the imidazolines tested. Flumioxazin was shown to have potential in an U.S. Army Corp screening but we found it did not perform well. Carfentrazone applications at rates that performed well on giant bur-reed (*Sparganium eurycarpum*) in cultivated wild rice were ineffective on Bohemian knotweed. Flazasulfuron activity observed in England was not observed in our first trial and glyphosate, as often seen, left questions as to whether plants will recover. These findings will be updated with a repeat of the trial. Additional work to inform herbicide optimization based on source-sink relationships will be discussed.

### **How can Adjuvants Improve Herbicide Efficacy?**

*Joe Vaillancourt; Loveland Products, Inc.*

Herbicide adjuvant is broadly defined as any substance added to the spray tank, separate from the herbicide formulation, that will improve its performance. Adjuvants can be added to a tank mix with a number of goals including: drift reduction, extending rain fastness, improving droplet uniformity, improving leaf penetration (especially for species with a thick leaf cuticle), improving adhesion, and overcoming challenges caused by hard water. This presentation will discuss a range of products that can be added to a tank mix to improve effectiveness and ultimately reduce the amount of herbicide needed per treated area to meet management goals.

### **Effectiveness of Herbicides when Controlling Golden Creeper (*Thladiantha dubia*)**

*Leo Roth\* and Mark Renz; University of Wisconsin - Madison*

Golden creeper (*Thladiantha dubia*) is an invasive perennial vine that reproduces via underground tubers. *T. dubia* has been present in Wisconsin for years, and in 2018 widespread populations were discovered in southwestern Wisconsin, primarily along river corridors. As little is known about effective management, we evaluated herbicides for *T. dubia* control in field and greenhouse experiments. In greenhouse trials, we grew *T. dubia* to a height of 20 – 70 cm. We then applied glyphosate (1,680 g ai ha<sup>-1</sup>) (Roundup PowerMax), imazapyr (280 g ai ha<sup>-1</sup> or 560 g ai ha<sup>-1</sup>) (Arsenal), and metsulfuron (126 g ai ha<sup>-1</sup>) (Escort), replicating each treatment on

seven plants. By 2 months after treatment (MAT), Escort and the high rate of Arsenal caused 100% necrosis in all plants and at 4 MAT no basal resprouting occurred. However, Roundup PowerMax and the low rate of Arsenal caused minimal necrosis (<40%) and resulted in basal resprouting at 4 MAT. In the field, we applied Roundup PowerMax (2% and 3% volume/volume [v/v]), Arsenal (0.5% v/v), Escort (3.8 g/L), Garlon 4 (1% v/v), Method (0.5% v/v), and Milestone (0.33% v/v) (Milestone), at both a late summer and fall application timing, with four replications per treatment. Although all summer applications except for Arsenal and Milestone provided > 85% control at 1.5 MAT, by 12 MAT only Garlon 4 continued to provide 85% control. Effective fall treatments at 12 MAT included Garlon 4 and Escort, both of which provided >90% control. While results suggest Garlon 4 in summer and fall and Escort in fall are effective, additional research is needed to validate the response and optimize the rates and application timings.

## **WIGL Summit 1: Welcome to WIGL - Who, What, Where, Why & How?**

### **Welcome to WIGL!**

*Clair Ryan; Midwest Invasive Plant Network*

Thank you for attending the Woody Invasives of the Great Lakes Collaborative Summit (WIGL Summit), a component of the Upper Midwest Invasive Species Conference! This talk will kick the summit off by introducing the WIGL Collaborative, its main goals, partners, the methods engaged so far, and what the future might hold. We will look at some basic mechanics of the new WIGL Collaborative website, and look at some data showing what interactions with the site look like so far. Finally, we'll have some actionable tips for what you can do to help stop the spread of woody invasive plants no matter who you are or where you come from.

### **Restoring Invaded Forests: Ecological Impacts of Woody Shrubs**

*Sara Kuebbing; University of Pittsburgh*

Some of the most prominent nonnative, invasive plants in Northeastern U.S. deciduous forests are woody shrubs and vines. These species can create dense, impenetrable thickets and have a wide range of ecological, economic, and human health impacts. In this talk, I will review the varied impacts woody invaders can have on our forests, as well as discuss restoration outcomes for controlling these species. I will also share some new data indicating how woody shrub spring leaf emergence phenology is shifting relative to native shrubs and canopy trees in response to climate change.

### **What Does the Forest Inventory and Analysis Program tell us about Woody Invasive Species Distribution?**

*Randy Morin, USDA Forest Service*

### **Woody Invasives of the Future Great Lakes - EDDMapS Predictive Tools Demo**

*Clair Ryan; Midwest Invasive Plant Network*

Recently, Dr. Jenica Allen of Mount Holyoke College, in collaboration with other scientists and extension educators, developed range shift estimates for almost 900 species of terrestrial invasive plants. These estimates use thirteen different climate change models and invasive species distribution data contained in the Early Detection and Distribution Mapping System (EDDMapS) to estimate where invasive plant ranges are likely to expand, contract, or remain unchanged in the 2040-2060 timeframe. Dr. Allen's abstract on this work is part of the Climate Adaptation session (Monday afternoon session). These estimates are most easily visualized on

maps, which were recently integrated into the EDDMapS website. The range shift mapping tools allow the user to adjust the acceptable level of uncertainty by selecting how many models must agree on climate suitability at any given location. The mapping tool also contains view showing uncertainty for all species with range shift estimates. There are some limitations of this approach as it only addresses the impacts of climate (temperature and precipitation patterns) on species range. It does not integrate other factors, such as soil type, disturbance level, or light availability, which also constrain where plants can grow. That said, the maps provide a user-friendly tool for visualizing which invasive species are likely to gain and lose ground due to climate change over the coming decades. During this talk, we will look at some woody invasive species likely to expand and contract their ranges in the Great Lakes Basin using the range shift maps in EDDMapS.

### **The WIGL Collaborative's Tools for Understanding and Managing Woody Invasive Species of the Great Lakes**

*Susan Franklin\*, Clair Ryan; Midwest Invasive Plant Network*

Here we will showcase some of the WIGL Collaborative's web-based tools to help users learn about and manage woody invasive species. We will look at the anatomy of a woody invasive species profile page, and how to use it, as well of as the linked resources, to make a confident identification, and to understand the species biology and invasive threat. We will use our map visualization tool to better understand how invasive woody plants are regulated in the Great Lakes jurisdictions. Then we'll look at the best management practice pages that will help landowners and managers develop a plan of attack.

## **THURSDAY LATE MORNING CONCURRENT SESSIONS**

### **Phragmites Symposium 2: Future Directions for Research & Management**

#### **The *Phragmites* Adaptive Management Framework: Managing *Phragmites* with Science on Your Side**

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Effective *Phragmites* management remains an elusive goal throughout the Great Lake Basin. The same management actions implemented in different areas may vary dramatically in their efficacy, and it isn't always clear why. To help improve *Phragmites* management across the Basin, the Great Lakes *Phragmites* Collaborative established the *Phragmites* Adaptive Management Framework (PAMF). Through a systematic approach, PAMF engages *Phragmites* managers and their efforts to develop best management practices and provide site-specific management guidance that is based on the results of past management efforts. Management guidance is produced through the implementation of the PAMF model, which utilizes annual participant data to predict *Phragmites* management outcomes based on site conditions. PAMF is now in its fourth iterative cycle and has hundreds of management units held by private, local, state, provincial, and federal participants across the Great Lakes Basin. This presentation will focus on reflections and major findings (e.g., the annual refinement of the PAMF model) from implementing an adaptive management approach to invasive *Phragmites* management and provide interested managers an opportunity to get involved.



## **Introducing Biological Control of Introduced Common Reed (*Phragmites australis*) in Ontario**

Michael McTavish<sup>\*1</sup>, Sandy Smith<sup>1</sup>, Rob Bouchier<sup>2</sup>; <sup>1</sup> University of Toronto; <sup>2</sup> Agriculture and Agri-Food Canada

Introduced *Phragmites australis* (common reed) is one of the most invasive plants in North America. Existing management is costly, can negatively affect other species, and is often only effective for smaller infestations. Classical biological control (i.e., introducing herbivores from the weed's native range) is a promising tool for *P. australis* management that can contribute to a broader program of integrated pest management (IPM). Following the approval for the release of stem-boring noctuid moths highly specific to *P. australis* (*Archana neurica* and *Lenisa geminipuncta*) in Canada, our goals are to develop and experimentally test the protocols needed to implement biological control of introduced *P. australis* in southern Ontario at a pilot scale. Using a combination of laboratory and field experiments, our objective is to determine the optimal methods for: (a) rearing and storing; (b) releasing; and (c) monitoring the impacts of these biocontrol agents, paying particular attention to the subspecies level specificity of the agents to introduced *P. australis australis* over non-target, native *P. australis americanus* in the field. As a part of the first biological control program enacted against introduced *P. australis*, we hope to help develop a promising new tool for managing this challenging, widespread, and costly invader.

## **Targeting Gene Expression to Develop Species-specific Approaches to Manage Non-native *Phragmites***

Kurt Kowalski<sup>\*1</sup>, Ping Gong<sup>2</sup>; <sup>1</sup> U.S. Geological Survey; <sup>2</sup> U.S. Army Engineer Research and Development Center

The non-native common reed (*Phragmites australis*) continues to invade the upper Midwest and is a growing management priority for resource managers. It degrades critical fish and wildlife habitats, reduces property values and beach access by landowners, increases fire hazards, clogs marinas and waterways, and increases roadside maintenance for transportation managers. Conventional management approaches (e.g., herbicide, cutting, burning, flooding) aren't species specific, are not available to all users, and can be very expensive, so innovative approaches including insect biocontrol, microbial symbiosis, and genetic biocontrol are being developed. A collaborative team lead by the U.S. Geological Survey, U.S. Army Corps of Engineers, and Wayne State University is developing a new species-specific, non-heritable control strategy for the non-native *Phragmites* that is based on the natural plant process of RNA interference (i.e., gene silencing) and lays a foundation for adaptation for other invasive plant species (e.g., cheatgrass, kudzu, Oriental bittersweet). The team is currently refining the delivery of genetic material to the plant cells through extensive laboratory testing and optimizing inhibition of gene expression as we transition into greenhouse and field studies. New treatments based on these technologies will offer managers additional options for managing *Phragmites* throughout the landscape.

## **Microbial Intervention for *Phragmites* Management: Progress and Possibilities**

Wesley Bickford<sup>\*1</sup>, Kurt Kowalski<sup>1</sup>, James White<sup>2</sup>, Keith Clay<sup>3</sup>; <sup>1</sup> U.S. Geological Survey; <sup>2</sup> Rutgers University; <sup>3</sup> Tulane University

All plants interact with a diverse suite of microbes that inhabit the soils surrounding them and live on or within their tissues. These interactions can either be beneficial to the plant or detrimental. Over the past several years, our research group has been studying which microbes interact with *Phragmites*, their functions, and how these interactions differ from those in native plant communities. If beneficial *Phragmites*-specific microbes can be inhibited or detrimental microbes enhanced, it will open up new control opportunities for land managers to add to their arsenal. We have developed a science agenda to answer a linked set of questions about the composition of *Phragmites*' microbiome, its functional capacity, and options for microbial manipulation. We assembled a team of scientists to tackle specific research questions with the ultimate goal of developing microbe-based *Phragmites* management techniques. Findings point to an important role for *Phragmites*-based microbes in

stress tolerance and nutrient uptake. We will share highlights from what we have learned across multiple experiments, including results of preliminary microbial inhibition studies that show promise for *Phragmites* control.

### **Is there a New Wetland Invader in Ontario? Assessing Potential Hybridization in *Phragmites***

Joanna Freeland\* and Abigail Warren; Trent University

Early detection of alien invasive taxa can greatly improve the likelihood of successful control, and managers are therefore continually monitoring for novel invaders which can include newly introduced species, or increasingly successful hybrids. The Eurasian *Phragmites australis* is a problematic invasive species that dominates North American wetlands over a broad geographical area, where it is often sympatric with the native subspecies *Phragmites australis* subsp. *americanus*. In southern Ontario, conservation managers at multiple sites have wondered whether stands of *Phragmites* that resemble the native subspecies, but appear to be growing in a dominant manner more consistent with the introduced lineage, could in fact be hybrids of the two lineages; if true, this would raise the possibility of newly invasive hybrid *Phragmites*. Conservation managers in southern Ontario therefore provided us with leaf samples from 127 *Phragmites* sampled from "questionable" stands growing at nine different locations. They also recorded morphological characteristics such as stem colour and glume length that can differentiate native and invasive lineages. We genotyped these plants at seven microsatellite loci, and compared the genetic and morphological data to previously generated data from known native and invasive *Phragmites*. We concluded that 114 of the plants were native *P. a. americanus*, and the remaining 13 were invasive *P. australis*; we therefore found no evidence that Ontario wetlands are being invaded by *Phragmites* hybrids. Our results agree with earlier studies which found that *Phragmites* hybrids are very rare in eastern North America, and suggest that the ecology of the native American subspecies is not fully understood. Conservation planning may benefit from future research into factors that promote different growth behaviours in native *P. a. americanus*.

### **Organisms in Trade: Fostering Responsible Consumers**

#### **Incidence of Red-eared Slider (*Trachemys scripta elegans*) Surrender to Minnesota Herpetological Society**

Jorge Polanco\* and Jeff LeClere\*; Minnesota Herpetological Society

The most popular turtle species that is farmed and sold is the red-eared slider (*Trachemys scripta elegans*). The red-eared slider is often found at pet stores being sold at a relatively low cost. In addition, they are often sold to new owners when they are small, even though there is a US Food and Drug Administration (FDA) ban on the sale of turtles with a carapace length of less than 4 inches. The combination of high abundance and low cost has made this animal extremely popular in the pet trade. Due to the animal's popularity, long life span, and relative adaptability to survive a wide range of conditions the red-eared slider often becomes an unwanted pet. In Minnesota, the red-eared slider is classified as a Regulated Invasive Species and is on the watch list of the Minnesota Invasive Species Advisory Council (MN DNR, 2020).

The Minnesota Herpetological Society (MHS) is a state non-profit organization whose goal is education but also runs an intake and adoption process for reptiles and amphibians. The red-eared slider is over-represented during MHS hosted intake events. These intake events provide a small sample population of people who no longer desire to keep the red-eared slider as a house pet but seek out an appropriate alternative. In fact, many people incorrectly believe that the red-eared slider is native to Minnesota and release them into the wild. Other people are just apathetic and want to get rid of an animal whose care requirements often surpass what an owner is willing to provide. Their status in Minnesota makes it illegal to release them into the wild. Despite this, these turtles have

been found in several lakes and ponds and have been found to successfully overwinter in Minnesota. This presentation provides information on a problem that shows no evidence of going away on its own. We recommend the red-eared slider's status in Minnesota be upgraded to Prohibited Invasive Species.

### **Expanding Invasive Species Prevention through Unique Community Partnerships**

*Doug Jensen\*<sup>1</sup>, Randy Carey\*<sup>2</sup>, Jeff LeClere\*<sup>3</sup>, Bartley Blume\*<sup>4</sup>; <sup>1</sup> University of Minnesota Sea Grant Program; <sup>2</sup> Minnesota Aquarium Society; <sup>3</sup> Minnesota Herpetological Society; <sup>4</sup> Bent Brewstillery*

Successes in invasive species prevention continue to build upon new partnerships. Recently, the Minnesota Sea Grant Program used unique approaches to achieve mutual goals in meeting community needs. This panel discussion will focus on three partnerships to promote Habitattitude prevention messages. Sea Grant formed new partnerships with Bent Brewstillery, Bent Paddle Brewery, Lake County Soil and Water Conservation District, Wildlife Forever, Animal Allies Humane Society, World of Fish, Minnesota Aquarium Society, Minnesota Herpetological Society, and others.

Minnesota DNR supported Sea Grant and partners to co-host three public crayfish boils of locally caught invasive rusty crayfish and imported red swamp crayfish. More than 2,650 pounds of invasive crayfish were consumed by patrons at crayfish boils, while they were served a ""helping"" of prevention actions and regulations - aimed at preventing release of unwanted pets, and crayfish intended for boils and fishing bait.

Sea Grant formed three Habitattitude Surrender Collaborative Networks, one in Duluth and two in the Twin Cities. Those networks hosted 14 Surrender events, which resulted in rehoming and reuse of 1,300+ aquarium fish, plants, invertebrates and reptiles. These events helped prevent potential release of unwanted animals and plants into the environment where they could have caused damage to our environment, recreation and economy. Both efforts engaged new partners, built capacity and extended prevention messages to audiences whom we would not otherwise have been able to reach. Come learn from this panel of partners about lessons learned and explore how these collaborative efforts could be beneficial to your AIS efforts.

### **Plant-Smart Water Gardening**

*Janet Schreier; Minnesota Water Garden Society*

Many homeowners add water features to their landscapes. If planted correctly, these water gardens develop a natural ecosystem that is beautiful to behold and requires very little maintenance. What characteristics of plants make this possible? What plants are commonly available to purchase? Which plants would be great, but are difficult to find in the nursery trade? How can homeowners ensure aquatic hitchhikers don't come in on their purchased or traded plants? Learn the behaviors and goals that drive residents to do what they do, and what is needed from the industry to prevent people from spreading aquatic invasives.

### **A Trusted Spokesperson Can Amplify Your AIS Prevention Message**

*Jeanne Scherer\*<sup>1</sup> and Melinda Myers\*; <sup>1</sup> University of Wisconsin - Madison Extension*

A trusted spokesperson can be key to getting people to listen and respond to your prevention message. Trust is influenced by the degree of trust, the audience's recognition of their expertise, their position of leadership, or general likability. Finding a trusted spokesperson to present invasive species prevention messaging can increase the possibility that listeners will change behaviors that can spread invasive species throughout our landscape. Wisconsin's Aquatic Invasive Species (AIS) Outreach Program produced four videos in 2019 with national

recognized gardening expert Melinda Myers and her team to reach those who potentially spread AIS through water gardening. In Wisconsin, there have been several responses to prohibited species due to water garden releases or displacement and to discoveries of prohibited species in private ponds. Melinda's videos provide advice on choosing non-invasive plants and disposal of problem plants. We will share the process, how the program has utilized the videos and at least one of the videos.

### **Invasive Crayfish Enforcement in the Live Food and Pet Industries**

*Robert Stroess; Wisconsin Department of Natural Resources Bureau of Law Enforcement*

The live food trade and the pet trade funnel hundreds of thousands of exotic crayfish into Wisconsin and surrounding Great Lakes states annually. Red swamp crayfish, marbled crayfish, yabby crayfish, electric blue, black sapphire, neon red, thunderbolt lobster, Mexican mini . . . the list goes on and on. They are available at the click of a mouse, and shipped to your local specialty grocery store, pet store, or your own front door. Find out what's being done by conservation law enforcement to combat the illegal trade in these exotic invasive species.

## **Diversity, Equity, Inclusion & Justice: Change-makers in the Midwest & Beyond**

### **Removing Social Biases from Conservation by Addressing Internal Cultures and Changing the Hiring Pipeline**

*August Ball; Cream City Conservation*

### **Environmentalists of Color, Catalyzing Racial Equity in the Environmental Field through A Member-Driven Network**

*Raquel García-Álvarez; Forest Preserves of Cook County*

### **Conversations about Racism, Creating Dialogue within Ourselves and Our Organizations to Catalyze Change**

*Rowzat Shipchandler; Minnesota Department of Natural Resources*

### **The Roger Arliner (RAY) Young Diversity Fellowship: Empowering Emerging Leaders of Color in Conservation**

*Guilu Murphy, RAY Diversity Fellowship*

## **WIGL Summit 2: The Importance of Biology in Managing Woody Species**

### **Nonnative Invasive Woody Species: What Makes Them So Successful?**

*Lauren Pile; USDA - Forest Service*

Nonnative invasive woody plants (NNIWP) have significant impacts to the diversity of understory ground flora and the regeneration of native trees in forests of North America. Further, NNIWP can encroach on grasslands, resulting in the functional replacement of grasslands to shrublands. These species have been introduced to the upper Midwest for a variety of reasons including as ornamental species, for land rehabilitation and wildlife habitat improvement, among others. Although not all nonnative woody plants become invasive, those that do can be among the most damaging of all invasive species by changing the structure, composition and function of our native forests and grasslands. Some of these woody species have only recently become naturalized or invasive resulting in much to learn about their general ecology, biology, and subsequently how to manage them effectively. However, several traits appear to be common among NNIWP. For example, most species are fast-growing, bird dispersed, and

highly fecund. Some species can limit the establishment and growth of other species thorough allelopathic compounds and some species are shade tolerant, allowing them to establish under mature forest canopies. Commonly, NNIWP are disturbance-dependent, thriving in habitats that have been altered by human or natural stressors. This talk will provide an overview of traits associated with NNIWP and the habitats they are most likely to invade including examples of species occurring in the upper Midwest.

### **Biology of the Callery pear (*Pyrus calleryana*) and Why it is so Difficult to Eradicate**

*Theresa Culley; University of Cincinnati*

Over the past 20 years, the introduced Chinese tree known as the Callery pear (*Pyrus calleryana*) has continued to steadily spread into natural areas throughout the United States. Originally sold in its cultivar form ('Bradford', 'Cleveland Select', 'Chanticleer', 'Aristocrat', etc.), this ornamental tree was one of the most popular landscaping trees in the 1990's. Eventually, it became known that these "self-sterile" cultivars and their rootstock are able to cross-pollinate and produce abundant numbers of fruits. Carried away and dispersed by birds such as the introduced European starling and the native American robin, these fruits and their seeds gave rise to dense wild populations located near urban locations in many areas of the country. In this presentation, we will explore the biology of this extremely hardy and tolerant species in terms of its reproduction, ecology, and genetics to better understand how the species might be best managed in natural areas. Ultimately, the Callery pear can be used as a case study to learn what can be done to prevent future plant invasions of other ornamental species.

### **Interactions between the Invasive Amur Honeysuckle, *Lonicera maackii*, and Overabundant White-tailed Deer, and Implications for Management**

*David Gorchov; University of Miami*

Amur honeysuckle, *Lonicera maackii*, is the most abundant invasive shrub in many forested areas of the Midwest, with well-documented negative effects on native plants, such as reductions in spring perennial herbs. Similarly, white-tailed deer in many areas of North America are much more abundant than in previous centuries, with negative effects on preferred herbaceous and woody plants and on tree regeneration. But we have only recently investigated the interactions between *L. maackii* and deer where both are abundant. Deer disperse viable seeds of *L. maackii*, although the importance of deer vs. birds in long-distance dispersal is not yet known. Deer browse on *L. maackii*, but it is a low preference food. However, during early spring when *L. maackii* has expanded leaves but native deciduous woody plants are still leafless, deer browse extensively on *L. maackii*, at least in areas with high deer density and depleted densities of more preferred species. Early spring *L. maackii* leaves provide protein at a time of high protein demand by does, and might sustain higher deer populations than would otherwise be supported in these forests. Our deer enclosure experiments where deer are abundant revealed that this browse reduces cover and growth of *L. maackii* shrubs, although net growth remains positive. This mitigation of the shading effect of *L. maackii* by deer is accompanied by a mitigation of deer browse by *L. maackii*: *L. maackii* shrubs enhance survival of seedlings of sugar maple and perhaps other tree species. Tree seedlings were most abundant where deer were excluded and *L. maackii* removed. Where both *L. maackii* and deer abundant, both should be managed. If one only removes *L. maackii*, this will expose 'hidden' tree seedlings to deer browse; reduction only of deer density will result in more shading from greater *L. maackii* cover. If these actions can't be done simultaneously, deer management should be done first, to avoid losing 'hidden' tree seedlings.

## **Some Native Shrubs can Mitigate Phenological Advantages of Invasive Buckthorn (*Rhamnus cathartica*)**

*Michael Schuster\*, Peter Wragg, Peter Reich; University of Minnesota*

Common buckthorn (*Rhamnus cathartica*) is an invasive shrub that dominates forest understories in the northern US and southern Canada. Its ability to invade is partially attributable to its high shade tolerance and ability to capture light both early and late in the growing season. Competitors that mitigate this phenological advantage may therefore increase biotic resistance against invasion. We compared phenologies of five native woody species to those of buckthorn in common garden experiments. Each experiment took place in an invaded oak-dominated forest where we planted common elderberry (*Sambucus Canadensis*), red elderberry (*Sambucus racemosa*), American hazel (*Corylus americana*), gray dogwood (*Cornus racemosa*), and sugar maple (*Acer saccharum*) as bare-root seedlings. Buckthorn were grown alongside native seedlings from seed. Spring phenology of buckthorn was often comparable to the five native species considered. All native species broke bud no later than 7 days after buckthorn, with red elderberry reaching spring phenophases consistently earlier than buckthorn. In autumn, native species started to senesce up to 20 days earlier than buckthorn, but both elderberry species senesced slowly and held their leaves equally long as buckthorn. Buckthorn growth and survival beneath woody plantings was reduced by up to 70% on average compared to unplanted areas. These findings illustrate that buckthorn does not possess unique phenology amongst understory species. Land managers and property owners in areas where buckthorn is a threat should seek to promote these species, particularly red elderberry, in order to limit invasion or re-establishment of buckthorn during management.

## **THURSDAY AFTERNOON CONCURRENT SESSIONS**

### **Invasive Carp: Modeling and Collaboration**

#### **Addressing the Invasion of Grass Carp in Lake Erie**

*John Navarro; Ohio Department of Natural Resources*

Grass carp pose an ecological threat to Lake Erie and its very valuable sport and commercial fisheries. The Great Lakes Fishery Commission's Lake Erie Committee (LEC) is using science-based adaptive management approaches to reduce the threat of grass carp by collaborating with researchers to reduce knowledge gaps to improve its targeted removal strategy. Grass Carp is an invasive species in the Great Lakes region and is one of four species commonly identified as "Asian Carp." Grass Carp present significantly different risks to the Lake Erie ecosystem than the Bighead Carp and Silver Carp currently found in the Illinois River system. Grass Carp are an important tool to control aquatic vegetation in place of chemicals and are actively stocked in low densities by private and public resource managers in states where allowed by regulation. Certified triploid Grass Carp are functionally sterile and provide an environmentally safer alternative to diploid fish by preventing establishment and sustained impacts. Previous detections of wild Grass Carp in Lake Erie were historically assumed to be escapees from triploid stockings, but successful reproduction of Grass Carp has been documented in the Sandusky and Maumee Rivers, increasing the risk that a grass carp population may become established. The LEC strategy builds on critical knowledge gaps that will improve targeted removal of this invader. Efforts are also underway to ensure the Grass Carp supply chain is free of fertile fish through routine testing of fish from the supply chain.

## **Adaptive Grass Carp (*Ctenopharyngodon idella*) Response Actions in Lake Erie**

*John Buszkiewicz\*, Lucas Nathan, Seth Herbst; Michigan Department of Natural Resources*

Grass Carp are one of four non-native carp species commonly referred to as "Asian carp". Grass Carp are distinct from the other species in that they have the potential to adversely modify aquatic habitats through consumption of vegetation. Grass Carp have been infrequently captured in Lake Erie since the 1980s. Although these feral captures were initially presumed to be sterile, captures of fertile diploids since 2012 and documented spawning since 2015 has elevated the concern of population growth, spread, and negative effects in Lake Erie and adjacent Great Lakes. To address these concerns, the Lake Erie Committee (LEC) developed a five-year adaptive response plan that was informed using a collaborative Structured Decision Making (SDM) process. Objectives within the response plan include implementing response actions to minimize population expansion, improving the understanding of Grass Carp dynamics to inform response actions, and minimizing the likelihood of introduction and establishment of new Grass Carp populations. Implementation of the plan involves collaborative, multi-jurisdictional efforts that address uncertainties using an adaptive management framework through evaluating effectiveness of established removal methods, telemetry studies, early life history surveys, and experimenting with innovative removal methods. Implementation of various response efforts has led to 187 diploid Grass Carp captures from Lake Erie since 2012 and continues to address critical uncertainties regarding life history and effectiveness of removal strategies. Each iteration of the adaptive response process leads to new information that helps refine strategies to maximize response efficacy and address Grass Carp concerns in Lake Erie.

## **Status of Grass Carp Spawning in Lake Erie Tributaries and Implications for Management**

*Nicole King\*<sup>1</sup>, Patrick Kocovsky<sup>2</sup>, Christine Mayer<sup>1</sup>, Song Qian<sup>1</sup>; <sup>1</sup> University of Toledo - Lake Erie Center; <sup>2</sup> U.S. Geological Survey*

Although grass carp (*Ctenopharyngodon idella*) have been captured in the Great Lakes since 1975, it was assumed that most were sterile or incapable of spawning in Great Lakes' tributaries. However, this assumption was questioned after several juvenile grass carp were captured in 2012 from the Sandusky River, a Lake Erie tributary. Initial spawning surveys were conducted in 2014 but yielded no evidence of grass carp reproduction. Spawning was first documented in 2015 with the collection of eight fertilized eggs in the Sandusky River. Monitoring continued and spawning was documented in 2017, 2018, and 2019, all correlated with high flow events. Spawning was documented in a second Lake Erie tributary, the Maumee River, in 2017, 2018, and 2019. Evidence of grass carp reproduction has increased interest in population control efforts and the need to locate spawning grounds. We used the Fluvial Egg Drift Simulator to back-calculate spawning location, which was later verified by the capture of several mature adults within, and early-developmental-stage eggs just downstream of the estimated spawning location during a spawning event in 2018. This work has informed multi-agency control efforts, allowing the targeted removal of adult grass carp from Lake Erie tributaries.

## **Identification of Probable Spawning Areas for Invasive Carps using Inverse Drift Modeling**

*Ryan Jackson\*<sup>1</sup>, Patrick Kocovsky<sup>1</sup>, Charlie Cigrand<sup>1</sup>, Nicole King<sup>2</sup>, Christine Mayer<sup>2</sup>, Song Qian<sup>2</sup>; <sup>1</sup> U.S. Geological Survey; <sup>2</sup> University of Toledo - Lake Erie Center*

Invasive Grass Carp (*Ctenopharyngodon idella*) are known to spawn in two tributaries to Lake Erie. A binational team of natural resource managers and researchers operating within a structured decision-making framework are fighting to control and/or eradicate this species from the Laurentian Great Lakes Basin. A key objective of the Lake Erie Grass Carp Adaptive Response Strategy (2019-2023) is identification of the primary spawning areas of these pelagic spawners so that control efforts can be focused, seasonal barriers can be implemented where feasible, and reproduction can be minimized. The capture of Grass Carp eggs in the Maumee River beginning in

2017 and the subsequent discovery of six Grass Carp larvae in the Maumee River in 2018 led to the development of a one-dimensional hydraulic model of the Maumee River coupled with the Fluvial Egg Drift Simulator (FluEgg), a biophysical Lagrangian particle tracker. Using FluEgg's reverse-time particle tracking algorithm, captured eggs and larvae that have been developmentally staged can be traced from their capture location to the most probable spawning location(s) upstream. This presentation will discuss the process, data requirements, and methods used to identify the most probable spawning areas for Grass Carp in the Maumee River. The methods presented are broadly applicable to inverse drift modeling of other invasive carps (silver, bighead, and black carp) and other pelagic spawning species in rivers and streams, provided the diameter and density of the eggs, as well as their temperature dependence, are known.

### **Using Collaboration to Prevent the Establishment of Asian Carps**

*Rebecca Schroeder\*<sup>1</sup> and Brook Schryer\*<sup>2</sup>; <sup>1</sup> Invasive Species Centre; <sup>2</sup> Ontario Federation of Anglers and Hunters*

Invasive Asian carps pose a significant threat to the ecological integrity and sustainability of the Great Lakes and Ontario's in-land waterbodies. Currently, there are no established populations of Asian carps in Ontario's waters and through a collaborative group known as Asian Carps Canada (ACC), led by the Fisheries and Oceans Canada (DFO), the group is working to keep the Great Lakes Asian Carp-free. One piece in ensuring we prevent the establishment of Asian carps is to educate Ontario's public about the risks and what Ontarians can do to help. To achieve this, ACC partners use a variety of outreach mechanisms including public information sessions, webinars, classroom outreach, trade show booths, and digital awareness such as social media and influencer marketing. More specifically, partners have created joint social media campaigns that have shown great success, achieving over 300,000 impressions across both organizations' social media platforms. The methods and execution of these collaborative campaigns demonstrate how multiple organizations can work together to share information in order to achieve greater reach with Ontario's public as we each work towards protecting our waters.

## **Promoting Behavior Change for Invasive Species Prevention**

### **Utilizing Technology to Understand the Effectiveness of Outreach Initiatives**

*Megan Pistoless\* and Brittney Rogers\*; The Nature Conservancy*

Raising awareness of the spotted lanternfly is key to preventing its spread into new regions. Many programs have engaged the public about this important issue through outreach initiatives, but how do we know if our strategies to raise awareness are effective? The St. Lawrence Eastern Lake Ontario Partnership for Regional Invasive Species Management has developed an outreach strategy that provides a targeted and measurable approach geared toward preventing the spread of the spotted lanternfly through behavioral change. Spotted lanternfly infestations have been established in six northeastern states and sightings of individuals have been reported in multiple other states along the east coast. The spotted lanternfly will have a significant impact on agricultural and tourist industries. Therefore, this invasive pest is considered a high priority prevention species on both a regional and national level. Our approach engages local businesses and their customers who are most likely traveling through known areas with established spotted lanternfly populations. Marinas, charters and outdoor sports stores are among the many businesses who are participating in this effort to prevent and slow the spread of the spotted lanternfly. Join the SLELO PRISM to learn more about this approach, how we have leveraged innovative technological tools to track our audience's knowledge of the spotted lanternfly and their willingness to take action to help stop its spread.



## **Wisconsin Boaters' and Anglers' Perceptions of Aquatic Invasive Species Prevention**

*Evelyn Hammond\*, Ayse Okur-Ozdemir, Tim Campbell, Jeanne Scherer; University of Wisconsin - Madison*

The Wisconsin Department of Natural Resources collaborates with research groups and volunteers to promote behaviors that help prevent the spread of aquatic invasive species (AIS). In 2009, 2013 and 2018, registered boaters and anglers in Wisconsin were surveyed to better understand their opinions and behaviors in terms of AIS prevention. The longitudinal nature of the study enables stakeholders to determine any changes that may have occurred in opinion and behavior over time. This abstract compares data for 2009, 2013 and 2018. It focuses on anglers' and boaters' perceptions of awareness, knowledge and familiarity of AIS, compliance with AIS steps, transience levels and preferred sources of AIS-related information. Current sources of AIS-related information are also investigated. Although, reported awareness of AIS, familiarity with AIS steps and compliance with AIS steps have increased since 2013, knowledge about AIS laws has decreased over the same period. These changes were statistically significant ( $p < .05$ ). Reported compliance with AIS steps has increased since 2009. While high transience levels among boaters and anglers decreased from 47% (2013) to 39% (2018), low transience levels increased from 53% (2013) to 57% (2018). In both 2013 and 2018, the majority of respondents chose Signs at boat landings as sources from which they had seen or heard about AIS-related information. In 2018, about 75% of respondents preferred obtaining information at a boat launch. AIS outreach efforts should be targeted at transient waterbody users and aimed at increasing users' knowledge about AIS laws through signs at boat landings and launches.

## **Developing a Clean Drain Dry Behavior Change Strategy in New York State**

*Ken Donnelly; Beyond Attitude Consulting*

To add a Behaviour Change component to its existing Watercraft Inspection Program, the New York State Department of Environmental Conservation embarked on a project to develop a human dimensions strategy. An online survey of 2700 registered watercraft users determined a very high level of awareness and a strong attitude towards protecting natural areas from invasive species. Insight into what motivates some people to Clean Drain Dry and what prevents others from doing so. Information gathered on boat movement, angling, marine services and other outdoor activities provide opportunities to refine outreach methods and target audiences.

## **Bridging the Gap: State and Local Behavior Change Initiatives for AIS Prevention in Minnesota**

*Tina Fitzgerald; Minnesota Department of Natural Resources*

Behavioral science shows us time and again that there is a gap between awareness and action. People may be aware of an issue such as aquatic invasive species (AIS) prevention, but they don't always act, adopt, or consistently practice desired behaviors over the long-term. Community-Based Social Marketing (CBSM) can help us bridge this gap. CBSM is a social science approach to foster sustainable, environmentally beneficial behaviors and provides a step-by-step approach for assessing risks and identifying opportunities for long-term change. As AIS program managers, CBSM tells us it is critical to understand the audiences we work with by directly gathering information about their knowledge, attitudes, behaviors, barriers, motivators, communication preferences, etc. specific to the activities they participate in and the AIS prevention actions we need them to adopt. The Minnesota Department of Natural Resources (DNR) Invasive Species Program contracted with CBSM experts to identify and prioritize AIS prevention behaviors and identify the barriers to and benefits of practicing these behaviors. Research included two online surveys; one concerning shoreline residents' movement of previously owned water-related equipment and one concerning anglers' use and disposal of live bait. Based on these results, the DNR is now administering a grant program for local governments to pilot behavior change intervention strategies. The collection of statewide baseline behavioral data combined with the local

implementation and evaluation of on the ground pilot projects will ultimately help promote the adoption of desirable AIS prevention behaviors and create positive social norms around AIS prevention throughout Minnesota.

### **Pathways to Partnership: How Three CISMAs Collaborated for Consistent Messaging**

*Rosie Page\*<sup>1</sup>, Lindsay Peterson\*<sup>2</sup>, Alix Bjorklund\*<sup>3</sup>, Tracy Beckman<sup>4</sup>; <sup>1</sup> Wisconsin Headwaters Invasives Partnership; <sup>2</sup> Wild Rivers Invasive Species Coalition; <sup>3</sup> Timberland Invasives Partnership; <sup>4</sup> Lumberjack RC&D Council*

From 2016-2019, three CISMAs in northern Wisconsin and Michigan worked cooperatively under a USFS Template 7a GLRI outreach grant to produce an educational guide about the pathways of invasive species spread in the upper Great Lakes region. Uniquely organized by user group, the guide is pocket-sized, colorful, and accessible to recreationists of all ages with various backgrounds. The project resulted in 1500 printed guides distributed 103 partner groups by the Timberland Invasives Partnership, Wisconsin Headwaters Invasives Partnership, Wild Rivers Invasive Species Coalition and our shared partner Lumberjack RC&D Council. Since locally-produced signage can often be more effective than state or federal, this regional guide focuses on our collective region of 11 mainly rural counties which have much in common and experience significant tourism each summer. During the process we acquired valuable lessons in collaborating across jurisdictional boundaries. By combining resources such as match dollars, software, skill acquisition (graphic design), and shared workload, we were able to maximize the strengths of each CISMA and create a product with consistent messaging on invasive species prevention across our management area. Working cooperatively also allowed us to navigate the unavoidable challenges of staff turnover and working on a timeline across significant distance. We encourage CISMAs to create regional partnerships beyond their borders; nonprofit groups are stronger when we collaborate and share resources. In addition to producing a high quality publication, throughout the grant duration we strengthened our working relationships between the CISMAs and with our mutual partner Lumberjack RC&D Council.

### **Diversity, Equity, Inclusion & Justice Panel: Conversations about Racism in Conservation**

This live panel discussion will feature Black, Indigenous and People of Color (BIPOC) panelists from many walks of life who have been involved in environmental science/conservation and organizations both large and small. Panelists will discuss their own experiences and encounters with racial bias and will discuss actions that make conservation organizations more welcoming to staff, leaders, volunteers and constituents of color.

### **WIGL Summit 3: The Trade Pathway - When Good Plants Go Bad**

#### **Indiana's Plant Assessment Process and its Vital Role in Development of the Terrestrial Plant Rule**

*Dawn Slack; The Nature Conservancy*

Recognizing the essential values and impacts of collaboration and partner support, Indiana uses a qualitative plant risk assessment process that follows, "The Invasive Species Assessment Protocol: A Tool for Creating Regional and National Lists of Invasive Nonnative Plants That Negatively Impact Biodiversity." Indiana uses a professional decision tree to assign risk to a nonnative terrestrial plant species. The assessment is subsequently reviewed by an assessment board that includes members representing land management, research, nursery and landscape

industries, forestry, regulatory agency and more. Species ranked high are then assessed for inclusion on Indiana's Terrestrial Plant Rule that is enforced by the Department of Natural Resources, Division of Entomology and Plant Pathology. The Terrestrial Plant Rule, passed in 2019 and effective as of April of this year, made it illegal to import and grow for sale 44 species of invasive terrestrial plant including several species of note to the WIGL Collaborative.

### **Use of Plant Sentry™ to Educate Consumers and Provide Plants that only Benefit the Environment**

*Tom Buechel <sup>1&2</sup> and Rachel Stewart <sup>2, 1</sup> Buechel Horticulture Solutions, LLC; <sup>2</sup> Plant Sentry*

The Green industry is thinking big to squash present and future invasive pest, disease, and invasive plant problems. Smart systems approaches including but not limited to regulation of invasive threats are vastly improving the odds of preventing future invasive problems and eliminating old ones. The evolution of SANC (Systems Approach to Nursery Certification) and Plant Sentry™ is changing the game on how we grow and ship plant product. Plant Sentry is a software product that standardizes plant nomenclature in nursery inventories to industry standards and cross-checks those names against all known jurisdictional regulatory restrictions. The end result of implementing Plant Sentry™ on the vendor level is automation of online sales systems that prohibit the shipment of plant species and cultivars to places where their transport or sale is prohibited. Outreach and education to consumers coupled with the use of tools like Plant Sentry™ will help motivate everyone to always search for acceptable plants for their area. You will learn how good teamwork helps accomplish the most daunting tasks and tricks to use in order to draw attention to invasive species programs. This engagement will increase your ability to convey the right message to consumers to promote your program and green goods that will keep gardeners happy for years to come.

### **Mislabeling and Hybridization: Untangling Invasive Bittersweet (*Celastrus orbiculatus*) from its Native Relative (*C. scandens*)**

*David Zaya; Illinois Natural History Survey*

### **Sterile Cultivars: A Plant Breeding Approach to Invasive Species Problems**

*Mark Brand; University of Connecticut*

Some species that are popular landscape plants can become invasive with time because the characteristics that allow for good performance in landscapes also can predispose a plant to become an invasive problem. One effective way to avoid invasive issues with landscape plants is to develop sterile, or seedless, forms of the species. Plant breeders can develop seedless plants by creating triploid forms of plants, by creating complex interspecific hybrids or through mutation breeding. To make triploids, breeders most often cross a natural diploid plant with an induced tetraploid plant. Tetraploids are produced first by exposing a diploid plant to a mitotic inhibitor, such as colchicine or oryzalin, to cause doubling of the chromosome sets. Another way to derive a triploid plant is to regenerate plants in vitro from isolated endosperm tissue harvested from a seed. The endosperm method only works for species that have large endosperms and for which in vitro shoot organogenesis or embryogenesis is possible. Use of wide interspecific hybridization is not always successful for all genera and interspecific hybrids can often look considerably different than the invasive plant they are intended to replace. Mutation breeding is a low yield method that requires production of very large numbers of individuals to derive a sterile plant with desirable ornamental characteristics. *Berberis thunbergii* will be discussed as a specific invasive plant for which breeding has been used successfully to create sterile forms of a popular landscape shrub.

## **Go Beyond Beauty: Northwest Michigan's Approach to Invasive Ornamentals**

*Katie Grzesiak; Northwest Michigan Invasive Species Network*

Join the Northwest Michigan Invasive Species Network (ISN) for an update on whole-community engagement in invasive plant prevention through the Go Beyond Beauty program. Launched in 2013, Go Beyond Beauty is ISN's ongoing and successful effort to engage garden professionals and the public in ornamental invasives management, removing key species from local trade through celebratory rather than regulatory means. This presentation will cover formation, structure, continued commitment, and plans for the future as well as resources, approaches, and changing demands from the industry and the public.

## **FRIDAY EARLY MORNING CONCURRENT SESSIONS**

### **Right-of-Way Invasive Plant Management**

#### **Documenting Impacts of Training Municipalities to Control Invasive Plants on Wisconsin Roads**

*Anne Pearce\* and Mark Renz; University of Wisconsin - Madison*

Many invasive plant infestations start in disturbed habitats like roadside rights-of-way (ROW) and then spread to high priority natural areas. ROW managers understand that controlling invasive plants is important to maintain safety along roads and to protect adjacent lands into the future. However, numerous challenges hamper their efforts including limited time and knowledge, budget constraints, and equipment access. Past efforts focused on educating state staff that oversee roadside management did not result in management changes. In 2019, we collaborated with university, private industry, and non-profit partners to facilitate five workshops across the state focused on managing invasive plants in ROWs. Attendees were trained via classroom and field sessions with large and small-scale ROW invasive species management demonstration plots. Classroom training included facilitated discussions on overcoming management obstacles. Demonstration plots illustrated response of local vegetation to the treatments over time. The workshops were attended by 233 representatives from 53 municipal and 25 county highway departments, state agencies, tribal governments, and CISMAs. Pre/post surveys were conducted to assess the workshops. Surveys suggest that attendees found classroom and field sessions useful and on average improved knowledge of core topics by 25%. Follow-up surveys showed that attendees manage > 19,000 road miles, and that 93% intend to change some element of vegetation management on their ROW as a result of attending our workshop. Additional surveys will track actual change in management practices and estimate the area impacted.

#### **Lessons Learned from Plant Growth Regulator (PGR) and Invasive Weed Control Roadside Programs**

*Jim Bean; BASF Corporation*

#### **Working with Counties & Municipalities to Control Invasive Plants on Roadsides**

*Lee Shambeau; 4-Control, Inc.*

## **Integrating Control Methods for Wild Parsnip (*Pastinaca sativa*) in Rights of Way with Imazapic + Metsulfuron for Grass Height Suppression**

*Leo Roth*<sup>\*1</sup>, *Mark Renz*<sup>1</sup>, *Lee Shambeau*<sup>2</sup>, *Ken Schroeder*<sup>3</sup>, *Jerome Clark*<sup>3</sup>, *Leigh Presley*<sup>3</sup>; <sup>1</sup> *University of Wisconsin - Madison*; <sup>2</sup> *4-Control, Inc.*; <sup>3</sup> *University of Wisconsin Extension*

We tested the effectiveness of nine herbicide-based and five mechanical management methods for controlling wild parsnip in rights of way (ROW). Because ROW vegetation is mowed two to five times per year in Wisconsin, we compared the effectiveness of imazapic + metsulfuron alone and in combination with other methods, as these herbicides reduce grass height. Herbicides broadcasted in May 2019 included aminopyralid (87 g ai ha<sup>-1</sup>) + metsulfuron (13 g ai ha<sup>-1</sup>) (Opensight), aminopyralid (142 g ai ha<sup>-1</sup>) + florasulam (12 g ai ha<sup>-1</sup>) (TerraVue), aminopyralid (199 g ai ha<sup>-1</sup>) (Milestone), metsulfuron (21 g ai ha<sup>-1</sup>) (Escort), aminocyclopyrachlor (140 g ai ha<sup>-1</sup>) (Method), 2,4-D (529 g ai ha<sup>-1</sup>) + dicamba (326 g ai ha<sup>-1</sup>), and indaziflam (40 g ai ha<sup>-1</sup>) (EsplAnade). Two treatments were applied as individual plant treatments (IPT), including 2,4-D (0.5% v/v) + dicamba (0.5% v/v), and glyphosate (1% v/v) (Roundup PowerMax). Mowing and hand removal treatments were included in addition to an untreated control. Treatments were replicated three times. Imazapic (66 g ai ha<sup>-1</sup>) (Plateau) + metsulfuron (32 g ai ha<sup>-1</sup>) (Escort) was applied to half of treated area. Opensight, TerraVue, Escort, and Method provided greater than 90% control of target species at 1.5 and 4 months after treatment (MAT). Mowing and IPT reduced viable seed production (>70% reduction in flowering plants), but control was poor by 4 MAT (<50%). Applications of imazapic + metsulfuron suppressed grass height by 44% at 1 MAT and by 34% at 3 MAT and provided control of wild parsnip comparable to high-performing herbicides, demonstrating that a range of tools control wild parsnip. Imazapic + metsulfuron shows promise as a tool for managers with limited budgets by providing effective control of wild parsnip while reducing mowing needs, resulting in lower ROW vegetation management costs than mowing alone.

## **Regulatory Toolbox for Invasive Species Prevention & Management**

### **Listing Noxious Weed Seeds in Minnesota: A Risk Assessment Model**

*Michael Merriman*<sup>\*</sup>, *Denise Thiede*, *Don Opdahl*; *Minnesota Department of Agriculture*

The Minnesota Seed Law limits the presence of noxious weed seeds in seed sold in the state by listing species as restricted or prohibited. The current list of prohibited or restricted species is published in the Rules based on a decision of the Commissioner of Agriculture and this list is difficult to change or manage in response to new threats. To improve the management of noxious weed seed lists and better align this list with the Minnesota Noxious Weed List when appropriate, Minnesota is proposing to formalize a Seed Program Advisory Committee, which will have the duty of conducting a risk assessment process on established priority species, species currently on the Minnesota Noxious Weed List, and eventually petitioned species. The list will be published on a three-year schedule. A risk assessment model developed to work for the seed industry will be presented and the relationship to the current noxious weed risk assessment model will be highlighted.

### **Timeline of Palmer Amaranth in Minnesota**

*Eric Yu*<sup>\*</sup>, *Shane Blair*, *Monika Chandler*, *Anthony Cortilet*, *Denise Thiede*; *Minnesota Department of Agriculture*

Palmer amaranth (*Amaranthus palmeri*) - a fast-growing, challenging to control noxious weed that significantly reduces crop yields - was first found in Minnesota in September 2016 in conservation plantings sown with Palmer amaranth contaminated seed mixes. Palmer amaranth was designated a Prohibited Eradicate Noxious Weed in 2015 and was regulated as a Noxious Weed Seed in 2017 by emergency order. A genetic test to help identify Palmer amaranth was simultaneously developed by multiple labs providing a tool to limit the spread as a contaminant in seed. Contaminated screenings fed to livestock led to contaminated manure spread on crop

fields resulted in new infestations. Limiting spread via these pathways was critical to successfully reducing the impact of Palmer. The Minnesota Department of Agriculture, University of Minnesota Extension, Conservation Corps Minnesota, private landowners, and other partners are working to eradicate these infestations before they spread. As a result of intensive scouting, flame weeding, prescribed fire, and herbicide applications in 2016 and 2017, only a handful of Palmer plants were found at three of the 30 plantings identified in 2016 then were eradicated. Similar success in 2018 and 2019 was achieved using the same methods. In addition to ground surveys and vegetation monitoring, U of M and MDA began conducting aerial surveys. MDA recorded management activities and documented a comprehensive timeline of Palmer amaranth in Minnesota. This timeline provides a story of success in combating Palmer amaranth.

### **Executive Action on Aquatic Invasive Species in the Great Lakes Basin**

*Kevin Irons; Illinois Department of Natural Resources*

The Great Lakes and St. Lawrence River system is shared by eight U.S. states and two Canadian provinces, contains about 20 percent of the world's surface fresh water, and supports a \$7 billion fishery. At the request of the Governors and Premiers, state and provincial experts, working with leading researchers, identified 21 Aquatic Invasive Species (AIS) as posing a high risk of invasion or spread within the region, resulting in a regionally recognized list of "least wanted" AIS. In recent years, the states and provinces have taken more than 50 separate actions to prevent the transfer of these high-risk AIS into the region. Fisheries managers and law enforcement officials support the least wanted list as a critically important tool in the fight against AIS. The Governors and Premiers also developed a Mutual Aid Agreement to facilitate cooperative response actions and the sharing of staff, expertise and resources if a new regional AIS threat is detected. More recently, all ten of the states and provinces have joined the Memorandum of Understanding (MOU) on Regional Cooperative Enforcement Operations. This MOU facilitates information sharing and cross-jurisdictional investigations and is an essential tool for law enforcement officials to act on AIS and other wildlife offenses. Leadership through the Great Lakes St. Lawrence Governors & Premiers, the region's chief executives, have shown that commitment to these issues results in solid outcomes for action to protect the region from high risk AIS. Partnering with neighboring regions could further embolden a solid strategy for future success, both for the Great Lakes and the nation.

### **The Success of Injurious Wildlife Listing Under the Lacey Act**

*Susan Jewell\*<sup>1</sup> and Pam Fuller<sup>2</sup>; <sup>1</sup> U.S. Fish and Wildlife Service; <sup>2</sup> U.S. Geological Survey*

For 120 years, the Lacey Act has prohibited harmful species, designated as injurious wildlife, from being imported into the United States. Since 1940, the U.S. Fish and Wildlife Service has had sole Congressional authority for designating species as injurious by regulation. Species that may be listed are wild mammals, wild birds, fishes, mollusks, crustaceans, amphibians, and reptiles that are injurious to human beings, to the interests of agriculture, horticulture, or forestry, or to the wildlife or wildlife resources of the United States. The effectiveness of injurious listings by USFWS has been described by non-USFWS entities who dwell on the apparent failures while ignoring the many preemptive successes. Here we evaluate the effectiveness of injurious listings with agency expertise. We quantify success by the effectiveness of listing relative to the stage of the invasion process - that is, whether a species was established at the time of listing, and if not, if it subsequently established. We analyzed the 309 species that were listed for invasiveness (excluding species listed for other injurious reasons). Only 6% were already established in the United States at the time of listing, and all remain established. The other 94% were listed preemptively (not established at the time of listing), and 100% remain not established. This constitutes a strong measure of prevention success for invasive species. We conclude that prohibiting the importation of high-risk species as injurious prior to their introduction and establishment is a highly effective component of achieving invasive species prevention.

## **Biological Control of Forest Pests**

### **Emerald Ash Borer Biological Control: A Management Strategy for the Forest**

Chris Mallet<sup>\*1</sup>, Angie Ambourn<sup>1</sup>, Jonathan Osthus<sup>1</sup>, Brian Aukema<sup>2</sup>, Rob Venette<sup>2&3</sup>; <sup>1</sup> Minnesota Department of Agriculture; <sup>2</sup> University of Minnesota; <sup>3</sup> USDA - Forest Service

Biological control of emerald ash borer (*Agrilus planipennis*) (EAB) was initiated in Minnesota in 2010 as a population control strategy applied to forested environments. Tree removals and insecticide treatments are effective management tools for EAB in urban environments but are not practical to implement on the forest landscape level. Emerald ash borer management in a forest setting is extremely challenging and -there are few viable options outside of biological control to actively manage the insect. Classical biological control offers a chance for the continued presence and viability of ash in forest ecosystems once the large mature overstory has succumbed to EAB. The goal of the EAB biological control program is to have the introduced parasitoid wasps reduce EAB populations to a low enough level so that young ash trees can survive long enough to produce seed and maintain ash as a component in forest ecosystems. Biological control release site characteristics play an important role in how well introduced parasitoid wasps establish and disperse. Minnesota Department of Agriculture staff has recovered parasitoids from multiple forested sites documenting establishment and natural spread. This presentation will focus on the goals of EAB biocontrol for the forest and what makes a location a good candidate for parasitoid releases.

### **The Continued Search for Associational Protection against Emerald Ash Borer**

Dora Mwangola<sup>\*1</sup>, Jennifer Burrington<sup>2</sup>, Angie Ambourn<sup>2</sup>, Mark Abrahamson<sup>2</sup>, Brian Aukema<sup>1</sup>; <sup>1</sup> University of Minnesota; <sup>2</sup> Minnesota Department of Agriculture

Emerald ash borer (EAB), *Agrilus planipennis* (Coleoptera: Buprestidae), is an invasive insect accidentally introduced to North America from Asia in the 1990s. EAB has been detected in five Canadian provinces and approximately three dozen American states, where it attacks and kills ash trees (*Fraxinus* spp.). The main control strategy employed in urban centers is the use of systemic insecticide treatments, which can be costly when treating large numbers of trees. This study investigates whether treating a proportion of a susceptible urban ash population will confer protection to untreated trees i.e. associational protection. We selected 12 sites in Minnesota in the summer of 2017 with known EAB infestation. Each site had approximately 100 trees. Eight sites had varying proportions of trees treated with emamectin benzoate and four sites had varying proportions of trees treated with azadirachtin. We are continuing treatments according to recommended specifications to determine associational effects of treated trees on untreated trees by monitoring tree crown health over time. Our study aims to contribute to developing more cost effective and environmentally favorable treatment regimes in urban centers.

### **Cold Tolerance and Overwintering Mortality of *Spathius galinae* in Minnesota**

Jacob Wittman<sup>\*1</sup>, Jian Duan<sup>2</sup>, Rob Venette<sup>1&3</sup>, Brian Aukema<sup>1</sup>; <sup>1</sup> University of Minnesota; <sup>2</sup> USDA - Agricultural Research Service; <sup>3</sup> USDA - Forest Service

*Spathius galinae* is a biological control agent against emerald ash borer that is native to the Russian Far East. As the native range of *S. galinae* extends further north than the native range of other parasitoids used in the biological control of emerald ash borer, it is thought that *S. galinae* may be well suited to surviving winters at more northern latitudes in North America, such as the Upper Midwest region of the United States. To test this hypothesis, we evaluated the cold tolerance of the overwintering larval stage of *S. galinae* in the laboratory by chilling larvae at different rates to different sub-zero temperatures and observing the temperature at which internal freezing occurred. After larvae were chilled, we assess survival by documenting larval discoloration and

adult emergence. We also exposed small logs that were infested with emerald ash borer to *S. galinae* adults and placed these outside in the fall of 2019 at three locations in Minnesota and a control location in Delaware, where *S. galinae* is known to successfully overwinter. We measured overwintering success by placing logs in emergence cages in spring and documented the number of emerged adults. We then peeled logs to assess the number of larvae that had failed to develop to adults.

### **Is There a Way Forward for the Biological Control of Common Buckthorn, *Rhamnus cathartica*?**

*Philip Weyl\* and Harriet Hinz; CABI*

Common buckthorn (*Rhamnus cathartica*) is a shrub or small tree of Eurasian origin, which has become invasive in North America where it is declared noxious in six US states and two Canadian provinces. The biological control programme was active between 2002-2012. From over 30 specialized insects identified from the target plant in its native European range, internal feeders and sap suckers were prioritized as potential biological control agents. During preliminary host range investigations many of the internal feeders that had been identified were not sufficiently host specific under no-choice conditions. Unfortunately, the choice-tests performed at the time yielded unreliable results. The sap sucking psyllids, were promising in terms of host specificity, but were infected with the plant disease '*Candidatus Phytoplasma rhamni*' rendering them unsuitable for introduction into North America. Considering common buckthorn's continuing environmental impact and the fact that it remains a very difficult species to manage using chemical and mechanical methods, it may be worth revisiting biological control. One of the lowest hanging fruits would be to repeat experiments with the psyllid *T. walkeri* to determine its role as a potential vector in the transmission of the phytoplasma. Additionally, fungal pathogens that have never been investigated, could offer new opportunities for the biological control of *R. cathartica* in North America. Despite the fact this invasive is not an easy target for biological control, there are options to potentially revive the efforts to manage common buckthorn using biological control.

### **Crown Rust Fungus Infects Two Wetland Invaders: Glossy Buckthorn and Reed Canarygrass**

*Nicholas Greatens\*<sup>1</sup>, Pablo Olivera Firpo<sup>1</sup>, Yue Jin<sup>2</sup>; <sup>1</sup> University of Minnesota; <sup>2</sup> USDA - Agricultural Research Service*

In spring of 2017, a crown rust fungus was observed near St. Paul, Minnesota on the invasive wetland plant glossy buckthorn (*Frangula alnus*). This fungus, identified by ITS sequencing as *Puccinia coronata* var. *coronata* (Pcc), infects leaves, petioles, flowers, pedicels, and young stem tissue, causing deformations of shoots, aborted flowers, loss of fruit, and defoliation. Pcc is heteroecious and macrocyclic, requiring two unrelated plant species to complete its life cycle and involving five spore stages. Aeciospores produced on glossy buckthorn infect reed canarygrass (*Phalaris arundinacea*), another invasive wetland species. Uredinial infections on reed canarygrass occur in early summer, causing premature senescence of lower leaves and reduction in photosynthetic capacity. Where the two hosts coexist, infection can be severe, causing near complete defoliation of glossy buckthorn and complete loss of fruit production. Less severe infection, apparently reducing but not eliminating seed production of glossy buckthorn has been observed across the Twin Cities. Pcc was likely recently introduced from Europe, and has been confirmed as far east as Massachusetts. Host specificity evaluations indicate that common buckthorn (*Rhamnus cathartica*) is resistant to Pcc, but several native North American buckthorn species, *Frangula californica* and *Frangula caroliniana*, are susceptible. In addition, preliminary tests have shown oats, rye, barley, and wheat to be unaffected or resistant to Pcc. Efforts are underway to delineate the host specificity of Pcc on both buckthorn species and grasses and assess its potential as a local augmentative biological control agent of one or both of its hosts.



## **WIGL Summit 4: Integrated Strategies for Woody Invasive Control**

### **Choosing the Right Tools for Mechanical Control of Woody Invasive Species**

*Chris Evans; University of Illinois Extension*

An infestation of woody invasive plants can take a lot of different physical forms. In a best case scenario, usually when it is caught early after introduction, there might be a few isolated seedling plants. In the worst case, these species can often form impenetrable thickets, dense with multiple invasive species co-occurring. The tools and methods a manager would choose to physically manage these two scenarios and the situations in between are very different. This talk will focus on choosing appropriate tools for physical control of a woody plant invasion based on site conditions and invasion severity. We will look at pulling and cutting tools, from hand-operated to high-tech. We will also discuss situations in which physical control of invasive woodies may be sufficient, and those when follow-up either with herbicide or other management practices will be necessary. Finally, we'll touch on the aggressive root-spreading species where attempts at physical control may do more harm than good.

### **Directed Flaming to Control Invasive Plants**

*Jeffery Ward; Connecticut Agricultural Experiment Station*

Control of invasive shrub and herbaceous species infestations can be accomplished using herbicides, mechanical cutting, or directed flaming, used alone or in various combinations. Directed flaming is accomplished with propane torches (flame weeders) to apply high-intensity heat to aboveground portions and root crowns of target species. Sufficient heat is applied to girdle stems and kill latent buds. The heating disrupts xylem tissues of herbaceous species and species with small stems, leading to eventual death of twigs and leaves by terminating upwards transport of water. Heat damage to larger stems may be limited to a wide band of phloem tissue; thereby eliminating photosynthate transport to the roots. Thus, mortality may be delayed for a year or more until the root systems exhaust their supply of stored carbohydrates and starve. We have found directed flame treatment is mostly effective for invasive species with buds or growing points proximal to the soil surface (i.e., barberry and stiltgrass) and for small seedlings. Those species with dormant buds or growing points below the soil surface are top-killed with directed flame treatments, but soon resprout. Larger, non-clonal woody species (e.g., winged euonymus, autumn olive) treated in late summer/early fall do not immediately die, but there are no sprouts when the top dies in late summer the following year. Surprisingly, directed flaming was also effective for two clonal species - bush honeysuckle and American beech. Pointers on effective use of directed flame treatment, susceptible species, and a special emphasis on appropriate and necessary safety procedures will be covered.

### **Integrated Management of Woody Invasives in a Remnant Forest Ecosystem**

*Kurt Dreisilker; The Morton Arboretum*

A remnant oak forest in northern Illinois has been the subject of many decades of invasive species control. Many people over many years have been using prescribed fire, herbicide, and various physical control methods to control over 20 different woody invasive species. This presentation will review lessons learned from various approaches to restoring this forested ecosystem.

## **Prescribed Grazing for Managing Invasive Woody Vegetation in Eastern Hardwood Forests**

*Ron Rathfon; Purdue Extension*

Prescribed grazing may offer an effective alternative to traditional methods of managing non-native invasive woody plants, but has received little study in forest settings. We varied the stocking (number of goats per treatment) and number of grazing periods within a growing season to determine effects of prescribed grazing on both invasive shrubs and native plant species in a mixed hardwood forest in southern Indiana. Specifically, we examined how varied stocking levels and grazing periods affect: (1) the cover and height of invasive shrubs (2) the cover and height of native woody species (3) the cover and diversity of herbaceous species, and (4) the density of native tree seedlings. Five successive years of prescribed grazing by goats reduced woody invasive cover by 32 to 50 percent. The greatest reductions in invasive shrub cover occurred in treatments with two grazing periods per growing season, regardless of goat stocking. While we observed mostly neutral or positive effects on the herbaceous layer, all grazing treatments reduced the cover and height of native understory woody species. Prescribed grazing is most effective within an integrated vegetation management system where instead of entirely supplanting mechanical or chemical treatments, it reduces labor and chemical costs.

## **FRIDAY LATE MORNING CONCURRENT SESSIONS**

### **On our Radar: New Terrestrial Invasive Plant Threats to the Upper Midwest**

#### **Carrot Family Identification, Part 1 - Smaller Species**

*Dave Hanson; Minnesota Department of Transportation*

We eat some of them; yet, others are poisonous or cause contact rashes. Some are native plants while others are invasive. Some are widespread invasive species that consume our management efforts while others are newly emerging early detection species. Learn how to identify invasive carrot family species (Apiaceae) and their native look alikes. Part 1 of 2 will highlight smaller family members such as: goutweed (*Aegopodium podagraria*), caraway (*Carum carvi*), Queen Anne's lace (*Daucus carota*), sweet cicely / anise root (*Osmorhiza* spp.), Burnett saxifrage (*Pimpinella saxifraga*), Japanese hedge parsley (*Torilis japonica*) and golden alexanders (*Zizia* spp.). Identification characteristics of the carrot family include structures like - schizocarps, umbels and umbellets, floral bracts and foliage that is compound to various degrees. We'll talk about stems that are mottled or green, smooth or ridged, hairy or not. All stems are hollow whether large or small. We'll try to cover it all. We'll learn about plants introduced as crops and others introduced as garden specimens. Some are native and it was stated by Ethnobotanist H.D. Harrington that one of those "has gained the reputation as being the most poisonous plant in the North Temperate Zone." Several family members produce contact poisons that cause phytophotodermatitis. Several species have limited distribution in the upper Midwest at this time. Bottom line, you need to work safe and work smart and that can only start with understanding the basic identification of the carrot family. Need to learn more? Then these sessions are for you.

#### **Carrot Family Identification, Part 2 - Larger Species**

*Dave Hanson; Minnesota Department of Transportation*

The second part of this series will highlight larger carrot family members such as: purple-stem angelica (*Angelica atropurpurea*), wild chervil (*Anthriscus sylvestris*), poison hemlock (*Conium maculatum*), water hemlock (*Cicuta maculata*), cowbane (*Oxypolis rigidior*), wild parsnip (*Pastinaca sativa*), cow parsnip (*Heracleum lanatum*) and giant hogweed (*Heracleum mantegazzianum*). Identification characteristics of the carrot family include

structures like - schizocarps, umbels and umbellets, floral bracts and foliage that is compound to various degrees. We'll talk about stems that are mottled or green, smooth or ridged, hairy or not. All stems are hollow whether large or small. We'll try to cover it all. We'll learn about plants introduced as crops and others introduced as garden specimens. Some are native and it was stated by Ethnobotanist H.D. Harrington that one of those "has gained the reputation as being the most poisonous plant in the North Temperate Zone." Several family members produce contact poisons that cause phytophotodermatitis. Several species have limited distribution in the upper Midwest at this time. Bottom line, you need to work safe and work smart and that can only start with understanding the basic identification of the carrot family. Need to learn more? Then these sessions are for you.

### **Public Gardens as Sentinels against Invasive Plants**

*Kurt Dreisilker\*<sup>1</sup>, Theresa Culley<sup>2</sup>, Clair Ryan<sup>2</sup>, Hans Landel<sup>3</sup>, Brittany Schultz<sup>4</sup>, Nadia Cavallin<sup>5</sup>, Roger Gettig<sup>6</sup>, Sai Ravichandran<sup>1</sup>; <sup>1</sup> The Morton Arboretum; <sup>2</sup> Midwest Invasive Plant Network; <sup>3</sup> Ladybird Johnson Wildflower Center; <sup>4</sup> Missouri Botanical Garden; <sup>5</sup> Royal Botanical Garden; <sup>6</sup> Holden Arboretum*

Public gardens can fulfill an important role in society by acting as sentinels for new invasive plants, particularly since many invasive plants originate from horticulture. This can be accomplished by collecting, synthesizing, and sharing data about how taxa spread from their original sites of cultivation into adjacent areas of their property. These data can be much more impactful if collected, structured, and shared using a common methodology. To this end, the Public Gardens as Sentinels against Invasive Plants working group has developed recommended guidelines to help gardens organize and share their data from their collections to characterize when plants escape from cultivation. PGSIP has also developed a database for gardens to upload and access information about plants spreading from cultivation. By collecting data from gardens across North America, PGSIP hopes to be able to provide a clear picture about plants escaping cultivation and potentially becoming problematic before large-scale invasions occur and before commercial adoption of these taxa into the broader horticulture industry.

### **Heads Up! What we can Learn From our Neighbors - Survey Results and Lightning Talks**

*Monika Chandler\*<sup>1</sup>, Kelly Kearns<sup>2</sup>, Chris Henze<sup>3</sup>, Clair Ryan<sup>4</sup>; <sup>1</sup> Minnesota Department of Agriculture, <sup>2</sup> Wisconsin Department of Natural Resources, <sup>3</sup> Johnson County Iowa Secondary Roads Program, <sup>4</sup> Midwest Invasive Plant Network*

This fall, we deployed a survey with the goal of learning what terrestrial plant species managers in the states and providences surrounding the Upper Midwestern U.S. consider to be the biggest up and coming threats. We asked them to consider not the ubiquitous species that are perhaps having the greatest impacts, but more recently introduced or discovered populations that are spreading quickly and causing concern. We asked respondents to report on the habitats these species are being found in and what they believe to be the primary vectors of spread. We received 47 responses that identified 66 terrestrial plant taxa. We will introduce and discuss some of the species we believe pose the greatest potential threat to the Upper Midwest that our neighbors are already tackling.

### **Workshop: R Statistical Software for Invasive Species Applications**

*Instructor: Matthew Russell; University of Minnesota*

Invasive species professionals are increasingly using data in new and complex ways. This hands-on workshop will provide an introduction to R software and how it can be used to acquire, analyze, and visualize invasive species data. This workshop will encourage and empower professionals to better use data to make strategic decisions

about invasive species. It will be especially valuable to graduate students who are at an early stage in their programs and professionals seeking to learn about the software and how it can be used in their work. Learning objectives: Learning objectives include (1) being able to discuss key concepts in data analysis with application to invasive species data and (2) being able to use R to import, analyze, and visualize invasive species data. Participant experience level: This workshop does not assume any prior experience with R.

## **Silvicultural Responses to Invasive Species**

### **Wisconsin's Emerald Ash Borer Management Toolkit**

*Colleen Matula\* and Paul Cigan\*; Wisconsin Department of Natural Resources*

Emerald ash borer impacts are now widespread in the southern half of Wisconsin and will become more common in the north as pest spread continues. This presentation will examine the recently-revised Wisconsin EAB silviculture guidelines, which can be used to prepare a stand for EAB or manage sites that are already impacted. In addition, we will review tools and reference materials that can aid in making management decisions.

### **Native Plant Community Silviculture Strategies Managing Black Ash Forests in Minnesota**

*Paul Dubuque\* and Mike Reinikainen\*; Minnesota Department of Natural Resources*

Past forest management in black ash communities has focused primarily on intermediate thinning or group selection removals in high quality pole-sized stands with the goal of maintaining uneven aged stands across the landscape. Even-aged clearcutting has also been applied but reforestation success has been mixed with the risk of understocked stands and conversion to non-forested communities an unfortunate reality. With the more recent discoveries of emerald ash borer (EAB) around Duluth and in Central Minnesota, the expectation that infestation will spread further into the forested part of the state, Minnesota DNR has provided direction to significantly increase the management of ash on state land. Although several states to the east are addressing the effects of EAB on their ash components in upland mixed hardwood forests, Minnesota is challenged by having an abundance of wet to very wet black ash dominated plant communities. An overview of the Division of Forest native plant community (NPC) silviculture strategies and case study examples will be presented.

### **Trees and Shrubs in Current and Former Oak Wilt Pockets**

*Brian Schwingler\*, Rachael Nicoll, Megan O'Neil, Eric Otto; Minnesota Department of Natural Resources*

Oak wilt is caused by the non-native fungus *Bretziella fagacearum*. It has been present in Minnesota for at least 75 years. Despite its duration in Minnesota, the long-term ecological impact of oak wilt has not been studied there or in the Lake States. Many landowners and managers choose to allow oak wilt to persist unhindered. To understand what the impacts could be of not managing stands with oak wilt, a pilot study was carried out in summer 2019 on the Anoka Sand Plain. Regeneration plots were placed in unmanaged oak wilt pockets and in clearcut, former oak wilt pockets. Control plots were placed in nearby locations unaffected by oak wilt. Results showed buckthorn density was higher in current oak wilt pockets and considerably higher in clearcut oak wilt pockets. The oak stem density in clearcut, former oak wilt pockets was four-fold higher (2,150 stems per acre) than in unmanaged oak wilt pockets. Also, the proportion of oak stems was higher in clearcut oak wilt plots (11 percent) over unmanaged oak wilt plots (5 percent). For wildlife managers, ecologists, and foresters, these results suggest clearcutting oak wilt-riddled stands may achieve management objectives over that of no management. Additional monitoring will reveal if native vegetation is able to successfully outcompete the abundant buckthorn.

## **Minnesota's Dwarf Mistletoes: Investigating a Novel Invasive Through a Native System**

*Ella Gray\*, Marcella Windmuller-Campione, Matthew Russell; University of Minnesota*

*Arceuthobium americanum*, a native dwarf mistletoe in the western US, is experiencing a range expansion across the boreal forests of Canada; infecting lodgepole pine (*Pinus contorta*) and jack pine (*Pinus banksiana*). Common in central Canada where the ranges for these two pines species overlap, in jack pine this dwarf mistletoe causes growth declines and eventual mortality in infested trees. Stand-level infestations have caused significant disturbance to jack pine forests and required aggressive control treatments in these systems. Though not yet known to be present in Minnesota, *Arceuthobium americanum* threatens the state's jack pine forests. To prepare for this novel invasive, we are studying an analogous, native system: eastern dwarf mistletoe (*Arceuthobium pusillum*) in black spruce (*Picea mariana*). Our approach is two-fold. First, using computer modeling, we are identifying risk factors associated with dwarf mistletoe infestation in Minnesota to predict stands at heightened risk. Second, using field work, we are characterizing differences in stand structure at differing levels of infestation to better understand the influence of dwarf mistletoe on stand development. Modeling results show density, diameter at breast height, basal area, and stand age to be the most important variables in predicting eastern dwarf mistletoe occurrence in Minnesota. Early results of field surveys show significant differences in stand structure and composition between differing levels of infestations. This work on a native, mortality-causing dwarf mistletoe will aid in planning for jack pine dwarf mistletoe if and when it enters Minnesota and enhances our ability to respond quickly to this new invasive species.

## **WIGL Summit 5: Herbicide Use to Control Woody Invasive Species**

### **Choosing the Right Application Method for Woody Invasives**

*Stephen Enloe, University of Florida*

Woody invasive plants are perennials with extensive root systems. This means that effective herbicide applications offer the best means of containment or eradication, because herbicides can kill roots without baring soil; bared soil is susceptible to reinvasion and erosion. Decades of research has found that herbicides tested and registered with the U.S. Environmental Protection Agency (EPA) are safe to humans and other animals when stored, transported, and applied according to strict label directions. This session will discuss the critical elements of treatment that help determine which application method is appropriate for a specific site, including target plant size class, selectivity (e.g. are there desirable/sensitive species nearby?), timing of when resources/labor is available to do the work, infestation density, and budget.

### **Choosing the Herbicide for Woody Invasives**

*Stephen Enloe, University of Florida*

Because nonnative invasive plants are usually difficult to control, selecting the most effective herbicide(s) is important. Often herbicides that have both soil and foliar activity are most effective with the least number of applications. However, applying herbicides with soil activity can damage desirable plants when their roots are present in the treatment zone or when herbicides move downslope to untreated areas following heavy rainfall. Triclopyr herbicides are mainly foliar active, but they have some soil activity when used at high rates or when mixed with oils. Certain herbicides can also vaporize in hot weather, and their residues can move by air currents to affect surrounding plants. Selectivity is also an important concern. Some herbicides are particularly effective on certain plant families and are less likely to have non-target impacts on species outside of those families. Damage to surrounding native plants can be minimized with care and forethought during planning and application.

## **Application Method Lightning Round & Industry Product Updates**

*Jim Bean, BASF Corporation*

*Jason Belcher, Bayer*

*Scott Flynn, Corteva Agriscience*

Representatives from three major agri-chemical companies will discuss best practices for various application methods used on woody species. The methods discussed will include low volume foliar application (spraying), stem injection techniques (“hack-and-squirt” and similar), low-volume basal bark application, cut surface/cut stump application, and dormant stem application. Speakers will also highlight any new products or label changes that impact the utilization of products for these methods.

## **FRIDAY AFTERNOON CONCURRENT SESSIONS**

### **Landscape Scale Management Approaches**

#### **Lessons, Experiences and Insights on Invasive Vegetation Management**

*Brandon Moore\* and Fugui Wang; Applied Ecological Services*

Applied Ecological Services (AES) has been working on invasive vegetation and wildlife species management for decades. AES has developed practical, cost-saving, and scientifically sound protocols for invasive species identification, quantitative analysis, treatment, and short and long-term monitoring. These protocols are based on extensive experience and lessons learned from numerous projects granted by private and public landowners for various interests. In this presentation, we will present information from those experiences and layout insights as to how the ecosystem could be restored and managed to slow down the spread of invasive species for good of the land and ecosystem integrity. Sharing what we've learned on managing invasive species, from the beginning steps of inventory and treatment to monitoring the long term effects, provides a stepping stone to collaborate and manage additional invasive species we haven't modeled yet.

#### **Innovative Control Methods and Tools to Control Invasive Species on Tribal Lands**

*Michael Arce; Oneida Nation - Environmental Health, Safety and Land Division*

The Oneida Invasive Species Program continues to research and implement new technologies and control techniques to help with the fight against invasive plants. Hiring freezes within the organization have forced our program to find new ways to accomplish more with existing staff levels. In addition to utilizing unmanned aerial vehicles (drones), we have been able to incorporate the use of a remote-controlled slope mower and an amphibious utility terrain vehicle (UTV) to access and control areas that were previously inaccessible. This presentation will focus on maximizing control efforts, incorporating technology, exploring herbicide options, and conclude with a video showcasing Oneida's Invasive Species Program in action.

#### **The Progression of Pulling Together: Becker County Cooperative Weed Management Area Plan 2006-2020**

*Marsha Watland; Becker County Cooperative Weed Management Area & Becker County SWCD*

The strength of the Becker CWMA comes from the engaged partners and their willingness to review yearly the Best Management practices for existing & new species that are added to Minnesota's Noxious Weed Law. In 2017 a Minnesota Department of Agriculture (MDA) Eradicate species Meadow Knapweed (*Centaurea x*

*moncktonii* C.E. Britton) was found in Becker County. The CWMA Partners quickly developed management plans. The introduction of new mapping system from MDA through EDDMaps Pro lead to developing an inventory process that meets the needs and requirements for County Agricultural Inspectors. Improvement of communication helped engage landowners on using cost-share effectively which included accepted management practices to be used long term. Working with landowners and community groups on effective herbicides for each weed species, timing of treatment and minimizing impact on environment. CWMA Partners are taking the lead on best management practices. The gravel pit certification program has grown from 23 to 75 certified gravel pits. Recreation flyers for the top seven weeds; Common Tansy (*Tanacetum vulgare* L.), Wild Parsnip (*Pastinaca sativa* L.), Leafy Spurge (*Euphorbia esula* L.), Meadow Knapweed (*Centaurea x Moncktonii*), Poison Hemlock (*Conium maculatum* L.), Plumeless Thistle (*Carduus acanthoides* L.) in Becker County are distributed by all partners for preventing spread of invasive terrestrial plants by landowners, recreation trail users and hunters. Becker County has seen a decline in MN Prohibited Noxious weeds with practices being transferred to additional areas in the County. Due to partner and landowner involvement, Meadow Knapweed abundance has been reduced in inventoried areas.

### **Challenges of Riverside Japanese Hop (*Humulus japonicus*) Eradication in Southeast Minnesota**

*Christina Basch*<sup>\*1</sup>, *Monika Chandler*<sup>1</sup>, *Emilie Justen*<sup>1</sup>, *Shane Blair*<sup>1</sup>, *Barb Perry*<sup>2</sup>, *Edward Dittmer*<sup>3</sup>; <sup>1</sup> Minnesota Department of Agriculture; <sup>2</sup> Minnesota Department of Natural Resources; <sup>3</sup> Conservation Corps of MN and IA

Japanese hop (*Humulus japonicus*) is an aggressive herbaceous vine that blankets and smothers native plants in pastures and riparian corridors. Since 2012, it has been designated a Prohibited Eradicate Noxious Weed by the Minnesota Department of Agriculture (MDA). In 2014, the MDA surveyed areas with historical reports of Japanese hop and found patches along the Root River & Harmony-Preston Valley State Trails in Fillmore and Houston counties. River surveys were conducted in 2015 to map the infestation extent along 70 river miles of the Root River. In the summer of 2015, a successful, full river treatment occurred. From 2016 - 2019, high water levels, erosion, and the lack of watercraft that can handle rapids, carry cumbersome equipment and maneuver undeveloped boat access sites hindered further management. The MDA, Department of Natural Resources and local partners are experimenting with different management techniques to overcome these challenges.

### **Lessons Learned in Starry Stonewort Management**

#### **The Starry Stonewort Collaborative**

*David Carr; Finger Lakes Institute*

The Starry Stonewort Collaborative enhances the capacity of experts, resource managers and local stakeholders to address starry stonewort (SSW) infestations across the Great Lakes basin. A key component of the project is a network of over 30 scientists, stakeholders and resource managers and 8 Expert Panelists from across the Great Lakes basin who help with outreach, resource exchange and project facilitation. Collaborator, panelist and citizen scientist work are grouped in three focus areas:

1) Ecology - sharing of ongoing field work and laboratory research for better understanding of *Nitellopsis obtusa* characteristics and life cycles; 2) Outreach - providing insights into the best outreach and education strategies for community involvement in SSW identification and reporting; and 3) Control - assisting in gathering and sharing best management practices and techniques from all areas of the GLB.

Outcomes achieved to date include the engagement of hundreds of community level volunteers and stakeholders across the GLB, development of a dedicated SSW website and online library, curation and dissemination of control strategies toward future development of BMPs for infestations of SSW throughout the GLB, collection and distribution of factsheets describing SSW and its control, preliminary literature review focused on

identification of commonalities and gaps in research, and information exchanges in the form of webinars, training, face to face meetings and discussions, conference calls, data gathering and cultivation of partnerships.

### **Predictive Modelling Assessment of Suitable Habitats for Starry Stonewort (*Nitellopsis obtusa*)**

Emily Neuman<sup>\*1</sup>, Sean Woznicki <sup>1</sup>, Kenneth Karol <sup>2</sup>, James McNair <sup>1</sup>, Sarah Hamsher <sup>1</sup>; <sup>1</sup>Grand Valley State University; <sup>2</sup>New York Botanical Garden

Since 1974 when the first population of starry stonewort (*Nitellopsis obtusa*) was discovered in the St. Lawrence River, rapid expansion in Michigan and seven other U.S. states has been recorded. This invasive macroalga has become a nuisance for native plants, animals, and recreational activities. Because most biological invasions are irreversible and eradication of invasive species is more difficult after establishment, early detection plans are an important tool in preventing and slowing the spread of invasive species. Macroscale data analyses have improved our ability to make predictions of changes in freshwater ecosystems and these types of data analyses are becoming increasingly important in incorporating the rapid expansion of invasive species. To determine suitable habitats that may be important to *N. obtusa* invasion and expansion at the macroscale level, a variety of physical, chemical and biological characteristics of lakes and watersheds within the Midwest and Northeastern U.S. with documented populations of *N. obtusa* are being analyzed. Species distribution models (SDMs) will be utilized to combine presence only records from the New York C. V. Starr Virtual Herbarium, Global Biodiversity Information Facility (GBIF) and Midwest Invasive Species Information Network (MISIN) of *N. obtusa* coupled with the Lake multi-scaled GeoSpatial and temporal (LAGOS) database. By using predictive SDMs, we anticipate that climate, habitat and landscape conditions suitable for *N. obtusa* will be uncovered and preventive early detection plans can be developed for management agencies to reduce the spread of this macroalga. Preliminary results of these analyses will be discussed.

### **Monitoring and Management of Starry Stonewort (*Nitellopsis obtusa*) in Wisconsin Lakes**

Michelle Nault; Wisconsin Department of Natural Resources

Starry stonewort (*Nitellopsis obtusa*; SSW) was first reported in the U.S. in the 1970s and has since been documented in portions of the eastern Great Lakes as well as various inland lakes throughout the Midwest. In September 2014, Wisconsin DNR staff discovered a small established population of SSW in a southeastern Wisconsin lake, marking the first time this non-native macroalgae had been reported in the state. Since then, SSW has been verified in over a dozen inland lakes in Wisconsin, as well as coastal portions of Green Bay and northern Lake Michigan. This presentation will highlight the statewide monitoring and management efforts which have occurred after the initial discovery, including an evaluation of management efficacy following the implementation of a variety of techniques (e.g., chemical control, drawdown, hand-removal, DASH, etc.) to control this new invader.

### **Multi-year Evaluation of Copper Sulfate and Hydrothol 191 to Control Starry Stonewort in a Central Minnesota Lake**

Kylie Cattoor\*, Keegan Lund\*, April Londo; Minnesota Department of Natural Resources

Starry stonewort (*Nitellopsis obtusa*) is an invasive macroalgae that displaces native aquatic plants and causes recreational disturbances in Minnesota lakes. Starry stonewort is currently isolated to 15 waterbodies in Minnesota and is considered a new invader but to date eradication efforts for starry stonewort have proved largely unsuccessful. Control strategies deployed in Minnesota include targeted hand pulling through SCUBA, herbicide applications using copper based algaecides and contact herbicides and diver assisted suction harvesting (DASH). In Medicine Lake a new infestation was discovered encompassing the public boat launch in



2018 and a control effort was initiated using repeated applications of copper sulfate and Hydrothol 191. The treatment area was extensively surveyed using a concentrated point-intercept methodology to measure changes in the distribution and abundance of starry stonewort and also submersed native macrophytes. This treatment regime was continued in 2019 and 2020 and has contained SSW from further in lake expansion. Biomass can be significantly reduced during the growing season through pesticide means. These efforts have provided nuisance relief for recreation and continue to minimize the risk of spread of starry stonewort in the Metro.

### **Large-scale Management of Starry Stonewort (*Nitellopsis obtusa*) in a Large Minnesota Lake**

*Christine Jurek\* and Emelia Hauck Jacobs; Minnesota Department of Natural Resources*

In 2015, the invasive macroalgae *Nitellopsis obtusa* (starry stonewort) was first discovered in Minnesota in Lake Koronis, Stearns County. Small-scale treatments were implemented prior to 2018; after which, the focus shifted to lake wide management using a combination of chelated copper (Cutrine® Plus) and mechanical harvesting. The impact of these lake-wide control methods for managing starry stonewort evaluated: 1) the effects of consecutive years of management on starry stonewort and native aquatic plants; 2) changes in biomass observed by method technique and 3) the impacts to bulbils following copper treatments. We detected a significant lakewide increase of starry stonewort following management with declines in native aquatic taxa frequency. In management plots, starry stonewort frequency of occurrence resulted in no significant change in pesticide, mechanically harvested and combined management plots. In contrast, there were statistically significant decreases in starry stonewort biomass after both six and eleven weeks post-management for both pesticide and pesticide & mechanically harvested plots, although these declines were not significant after the second treatment. The mechanically harvested plot also showed significant declines before and after management. Results from the bulbil counts suggest that copper treatments had no detectable effect following treatments. Measuring success is determined by goals and outcomes. This study demonstrates that biomass reduction can be achieved during a single growing season with repeated management, although the lack of significant reduction in the frequency of starry stonewort within a growing season and over multiple years may indicate that these control methods do not provide long-term control.

## **WIGL Summit 6: Public Perceptions & Engagement to be Part of the Solution!**

### **Best Practices for Public Engagement**

*Ken Donnelly, Beyond Attitude Consulting*

There are all sorts of ways that those of us in the invasive species field might wish that people and communities might change their behavior with respect to woody invasive species. With certain species that remain in trade like Callery pear, Norway maple and winged burning bush, we might wish that people would stop buying these plants for use in residential and commercial landscaping. With other species that are no longer in trade but persist in gardens and in private woodlands like multiflora rose, the Asian bush honeysuckles and buckthorn, we might wish that people would take the initiative to control these species, especially on properties nearby to protected natural areas. Getting people to change is difficult but not impossible. Modern outreach and education programs that result in meaningful change and public engagement employ a data-driven strategy to better understand peoples' concerns and motivations, and to overcome barriers to adopting more sustainable behavior. Ken Donnelly, an expert in modern environmental communication and behavior change, will explain the basics of this approach.

## **Engaging Private Residential Neighbors in Controlling Buckthorn to Benefit a Sensitive Natural Area**

*Mathew Ueltzen and Brett Peto, Lake County Forest Preserve District*

The Lake County Forest Preserve District has spent considerable resources to control the exotic and invasive tree, European buckthorn, within its preserves. Unfortunately, these preserves are under the constant threat of reinvasion from birds eating buckthorn berries on neighboring properties and carrying seeds over boundary lines. To truly solve this problem, we have come to the realization that we need to look outward as well as inward. The Forest Preserves' buckthorn eradication project aims to engage private property owners to manage buckthorn populations on their lands. To start this process, the Forest Preserves and its partners prepared a survey and sent it to all homeowners surrounding Middlefork Savanna Forest Preserve. The survey gauged the public's knowledge of buckthorn, and their willingness and capacity to manage it on their property. This talk will review the survey and its results, and also discuss our initial neighbor engagement efforts.

## **Just because it's Sold Doesn't Mean it's Good - Using Landscape Alternatives to make Good Plant Choices**

*Clair Ryan, Midwest Invasive Plant Network*

Unfortunately, many invasive woody plants are still for sale. While many smaller nurseries are doing the right thing by phasing out production and sales of invasive plants, we still have a long way to go to address sales through "big box" stores and online vendors. While regulation can be an important tool on the supply side, consumer education and empowerment is surely as important on the demand side of this issue. As part of the larger Woody Invasives of the Great Lakes Collaborative project, MIPN revitalized its approach to suggesting landscape alternatives. We have kept some of the elements that made our earlier work successful, such as producing both print and electronic materials, using engaging imagery, and suggesting many alternatives for each invader addressed. However, we are also using some new approaches, including explicitly calling out the shared ornamental traits between invasives and non-invasive alternatives and boosting U.S. and Great Lakes natives. From research and industry engagement to coding and photo curation, we'll walk you through our process and preview our results!

## **Tweet! Post! Like! Using Social Media to Promote Forest Health and Invasive Species Awareness**

*David Coyle, Clemson University*

Social media is an incredibly powerful communication tool that, if used properly, can help to amplify your message, reach new audiences, and promote your cause. Forest health and invasive species education and management can benefit from social media promotion, as this may help get new information to interested people. This talk will discuss how to use social media to promote forest health and invasive species, including how to reach new audiences, how to convey a message, and how to best craft social media posts so that your message reaches its full potential on that communication platform. We'll focus on Twitter, Facebook, and Instagram, and discuss what components make a good message.

## **Poster Abstracts**

### **2021 Invasive Species Calendar from the Minnesota Invasive Species Advisory Committee**

*Laura Van Riper<sup>1</sup>, Missy Anderson<sup>2</sup>, Jennifer Burington<sup>3</sup>, Sascha Lodge<sup>1</sup>; <sup>1</sup> Minnesota Department of Natural Resources; <sup>2</sup> Three Rivers Park District; <sup>3</sup> Minnesota Department of Agriculture*

Each year the Minnesota Invasive Species Advisory Council (MISAC) identifies key invasive species topics to be highlighted in a calendar targeted to natural resources professionals. The 2021 calendar identifies invasive species, pathways of spread, success stories, and other topics of interest to people of Minnesota and the Upper Midwest. The calendar is shared online and paper versions are given out to target audiences. Two success stories in the just-released calendar are purple loosestrife biocontrol and Cooperative Invasive Species Management Area (CISMA) work on Japanese knotweed. Species highlighted include emerging invasive species such as amphibian diseases, jumping worms, and winged burning bush along with species with a wider distribution such as oak wilt and mystery snails. The fish tench and the aquatic plant European frogbit are not known to be found in Minnesota, but have been identified as species of concern that should be reported if found. The mountain biking pathway, the waterfowl hunting pathway, and the holiday greenery pathway are three pathways of spread that are featured. The invasive species calendar is a colorful and fun way to share key invasive species information to help people prevent, report, and manage invasive species.

### **A Simple(r) Method to Measure PCR Inhibition by Environmental DNA Templates**

*Craig Jackson, Chris Merkes, and Jon Amberg; U.S. Geological Survey*

The sample matrix for environmental DNA samples can be a complicated mixture. DNA extraction techniques sometimes co-purify chemicals that may inhibit PCR enzyme activity, causing false negative results. Commonly, such inhibition is detected by adding a defined amount of an unrelated exogenous DNA sequence ("Internal Positive Control" or IPC; often synthetic copies of the mouse HemT gene) directly to the test reactions in multiplex format. The HemT starting copy number is calculated from a standard curve after amplification and compared to the spiked concentration to determine if the sample is inhibited. This method requires rigorous validation to ensure that each test qPCR primer/probe set functions properly multiplexed with the control HemT primers/probe. It also assumes that inhibition of the HemT reaction translates equivalently to inhibition of the test reaction. We propose a simpler and potentially more informative method to accomplish the same objective. Instead of multiplexing an exogenous IPC assay with the test assay, we prepare a separate subset of reactions spiked with 100 copies of the target sequence of interest. The advantages of this method are that no additional multiplex validation experiments (beyond the typical target assay validation) are required, and that inhibition of the specific test reaction is being assayed and not that of a competing substitute. We have successfully used this method to detect several invasive species by qPCR including Asian carps and Dreissenid mussels.

### **Advancing Host-plant Resistance for Sustainable Management of Soybean Aphid**

*Siddhi Bhusal, Robert Koch, and Aaron Lorenz; University of Minnesota*

The introduction of the soybean aphid (*Aphis glycines*) to North America has resulted in dramatic increases in insecticide inputs to protect soybean yields. The wide-spread use of broad-spectrum insecticides to manage this invasive insect adversely affects the environmental sustainability of soybean production. Deployment of preventive pest management tactics, such as aphid-resistant varieties, can decrease the likelihood of growers needing to apply insecticides to soybean fields. At least nine Rag ("resistance to *Aphis glycines*") genes of aphid resistance have been discovered so far, and soybean varieties carrying Rag genes have proven effective at suppressing soybean aphid populations and protecting soybean yield. However, availability of aphid-resistant

soybean varieties is extremely limited. At least four soybean aphid biotypes have also been identified, with three of them being virulent to one or more Rag genes. To increase the availability of aphid-resistant soybean varieties, and thereby reduce insecticide use, several breeding lines carrying different combinations of Rag genes are being developed by the University of Minnesota and being tested in advanced and regional trials for yield and other agronomic characteristics. Investigation of variation of soybean aphid biotypes revealed the variation of soybean aphid biotypes not only within a township but also within soybean fields in Renville and Kandiyohi County, MN. We found up to three soybean aphid biotypes within a single field. Therefore, development of aphid-resistant soybeans pyramided with multiple resistance genes is important for soybean producers to manage soybean aphid with decreased insecticide inputs, thereby improving economic and environmental sustainability of soybean production.

#### **An Update: Biological Control of Garlic Mustard with Crown-Boring and Seed-Feeding Weevils**

Elizabeth Katovich<sup>1</sup>, Roger Becker<sup>1</sup>, Ghislaine Cortat<sup>2</sup>, Harriet Hinz<sup>2</sup>, Laura Van Riper<sup>3</sup>, Mary Marek-Spartz<sup>1</sup>; <sup>1</sup>University of Minnesota; <sup>2</sup>CABI; <sup>3</sup>Minnesota Department of Natural Resources

Garlic mustard (*Alliaria petiolata*) is an invasive biennial plant native to Europe and, in North America, poses a threat to native herbaceous and woody plants in the forest understory. Biological control would provide long-term management of this invasive plant. Two of the most promising biocontrol insects are the European weevils, *Ceutorhynchus scrobicollis*, a crown-miner and *Ceutorhynchus constrictus*, a seed-feeder. The crown-mining weevil is predicted to have the most significant impact on garlic mustard plants. However, release of a single control agent is unlikely to control garlic mustard across its full range. It has been predicted that a combination of agents that simultaneously reduce rosette survival and seed production will be required to suppress the most vigorous garlic mustard populations. This is the rationale for developing the seed feeder, *C. constrictus* as a biological control insect. This seed-feeder can destroy up to 60% of developing seeds in a population of garlic mustard, reducing the severity of an infestation through a reduction in the seedbank. Host-range testing has been completed for *C. scrobicollis* and the agent has been recommended for release by the Technical Advisory Group for the Biological Control of Weeds and is currently under review by APHIS-PPQ. Host specificity testing of the seed-feeder is well advanced and so far, has shown a very narrow host range for this species. The biology of the two potential biocontrol agents, and their impact on garlic mustard plants are described in this poster.

#### **Biological Control of Emerald Ash Borer in Minnesota**

Patrick Walrath<sup>1</sup>, Angie Ambourn<sup>1</sup>, Jonathan Osthus<sup>1</sup>, Christopher Mallet<sup>1</sup>, Monika Chandler<sup>1</sup>, Brian Aukema<sup>2</sup>; <sup>1</sup>Minnesota Department of Agriculture; <sup>2</sup>University of Minnesota

Minnesota's use of biological control to help manage the population of emerald ash borer (*Agrilus planipennis*) (EAB) in landscape settings, dates to 2010. Since then, over 609,000 parasitoid wasps have been released at 47 EAB-infested sites in 11 counties across Minnesota. In conjunction with the Environment and Natural Resources Trust Fund and the USDA EAB Parasitoid Rearing Facility, the Minnesota Department of Agriculture released 47,616 parasitoid wasps (34,607 *Tetrastichus planipennisi*, 8,400 *Oobius agrili*, and 4,609 *Spathius galinae*) at eight EAB-infested sites in the Twin Cities, Duluth and southeastern Minnesota in 2019. Parasitoid recovery first occurred in 2013 and in subsequent years, larval and egg parasitoids have been recovered from 12 sites around Minnesota proving their ability to overwinter, establish, disperse and increase in population. In 2019, MDA successfully recovered parasitoids at five former release sites across Minnesota using whole tree sampling, bark sifting and yellow pan trapping methods. Winter bark sifting in early 2019 resulted in the recovery of the egg parasitoid *O. agrili* from three new locations: West River Parkway in Minneapolis, Whitewater Wildlife Management Area near Elba, and Farmers Community Park in Lewiston. The larval parasitoid, *T. planipennisi*, was also recovered at a new site, Farmers Community Park in Lewiston, using yellow pan trapping. Even though a harsh 2018/2019 winter may have decreased numbers of EAB, and subsequently, the associated parasitoids,

these recoveries along with releases in 2020 will allow these important biological control agents to continue to help reduce EAB populations in the forest landscape.

### **Building Resiliency in Black Ash in Preparation for Emerald Ash Borer**

*Colleen Matula and Graham Wessberg; Wisconsin Department of Natural Resources*

Black ash (*Fraxinus nigra*) wetland forests in the Upper Great Lakes are facing dramatic impacts. With the arrival of Emerald Ash Borer and stressors from climate change, forest managers are challenged by this forest type. Developing adaptive management is difficult with the limited information on the ecology and management in black ash forests. Although historically a low economic value species in Wisconsin, black ash forests provide many ecosystem benefits. Recently a proposal was funded by Great Lake Restoration Initiative (GLRI) to develop silviculture strategies in maintaining resilience in black ash wetland forests in the Lake Superior Basin. The project takes place on ten sites each about twenty acres in size. All sites are in four counties of northwestern Wisconsin. Prior management at sites ranged from being coppiced, strip clear cut or no harvest. Each site had a portion direct seeded in the winter of 2019 with five tree species. In the spring of 2020 four tree species were planted at each site. All ten sites had baseline data collected pre direct seeding in the winter of 2019. To assess deer browse, a 5 ft. by 5 ft. deer enclosure was installed and trees bud capped. Each year through 2024, data will be collected including tree survival, hydrology, and soils. In the fall of 2024, data will be analyzed and recommendations developed for land managers. This project addresses ways to prepare for and maintain forest cover and hydrologic function considering Emerald Ash Borer.

### **Comparison of Early Detection Survey Approaches during Two New Fish Introductions**

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A major component and challenge of aquatic non-indigenous species (NIS) prevention and management efforts is implementation of early detection monitoring (EDM) surveys. Assessing the performance of EDM surveys typically relies on surrogate performance metrics to estimate survey effectiveness absent any actual new NIS presence. However, models based on established or indigenous species may not be appropriate for evaluating detection effectiveness for new NIS. Recently, two newly introduced fishes, white bass (*Morone chrysops*) and gizzard shad (*Dorosoma cepedianum*), were detected in the St. Louis River estuary (SLRE) which includes the Great Lakes port of Duluth-Superior. Three different EDM survey approaches focusing on different biological targets (adult-juvenile, ichthyoplankton and eDNA) were ongoing during these introductions providing a rare opportunity to use actual NIS introduction data to compare and evaluate their effectiveness. Calculations of effort required to achieve 95% probability of detection (based on detection years) differed by survey approach but suggest that overall annual effort throughout the study provided 90-95% probability of detection for both species. Detection rates differed by EDM approach for both species. For example, eDNA appeared to be a more sensitive survey approach for gizzard shad while ichthyoplankton and adult-juvenile approaches appeared more sensitive for white bass. Relative detection in DNA-based (ichthyoplankton and eDNA) surveys versus morphological (adult-juvenile) surveys is discussed. Cohort calculations of captured fish suggest that white bass were present up to 5 years prior to initial detection while gizzard shad may have been detected in the first year of introduction.

### **Developing Airborne eDNA Technology to Detect Hemlock Woolly Adelgid (*Adelges tsugae*)**

*Meg Sanders and Charlyn Partridge; Annis Water Resources Institute, Grand Valley State University*

Hemlock woolly adelgid (*Adelges tsugae*), is an invasive insect threatening hemlock forests throughout the United States with populations confirmed in Michigan. Management efforts in Michigan are underway to control and stop the spread of this invasive pest, with a primary focus on early detection. Current methods for monitoring involve visual assessments of hemlocks for the presence of hemlock woolly adelgid (HWA) ovisacs which can be a considerable task for land managers given the estimated 170 million hemlock trees in the state. This project is testing the efficiency of a modified airborne environmental DNA (eDNA) method as an early monitoring approach in Michigan. The goal of this work is to construct affordable, efficient traps to capture airborne HWA material and develop a molecular assay for HWA detection. We will evaluate trap performance over the course of a year for accurately detecting HWA across different infestation levels and life stages of the insect. This technology could help preserve valuable personnel resources for HWA eradication efforts in Michigan as well as aid land managers in other states continuously monitoring HWA populations.

### **Developing a Water Gardener AIS Outreach Video Series with Melinda Myers**

*Jeanne Scherer, University of Wisconsin Extension and Melinda Myers*

It's an unusual year when Wisconsin Aquatic Invasive Species staff, their partners and volunteers are not called upon to help eradicate populations of escaped or released water garden plants in rivers and streams in the fall. Press releases and social media posts to the general public may or may not have helped us get the message out. Another tool can more directly reach water gardeners: videos which can be shared in gardening e-newsletters, through social media and at events. Four videos were created in a contracted partnership with Melinda Myers, a gardening expert who is well-known to Wisconsin gardeners and nationally. The longest video (embedded) is an overview of the problem and prevention actions water gardens can take. The three additional videos (linked below) are seasonal reminders of prevention steps.

### **Development of an AIS Outreach Video for a Waterfowl Hunter Audience**

*Jeanne Scherer, University of Wisconsin Extension and Chris Hamerla, Golden Sands RC&D*

Waterfowl Hunters can easily spread aquatic invasive species to the hunting areas they visit which include lakes, rivers and wetlands. Their boats, boots, decoys and dogs can all be vectors of spread. Doing direct outreach through boat inspection programs is difficult because the hunters are not as concentrated as recreational boaters and anglers. Working with UW Extension Lakes, Wisconsin Waterfowl Association and Golden Sands RC&D, two videos were produced to broaden our reach. The first teaches boat inspectors and other AIS Outreach staff about the sport and risks. The second is a direct message to the hunters. The YouTube video is shared by the members of the WI AIS Partnership, WWA and is on the Waterfowl Hunter Resources Page on the WDNR website.

### **Garlic Mustard Monitoring Efforts Inform a Coupled Weed-Herbivore Population Model for Simulating the Release of Potential Biocontrol Agents**

*Mary Marek-Spartz<sup>1</sup>, Roger Becker<sup>1</sup>, George Heimpel<sup>1</sup>, Lori Knosalla<sup>2</sup>, Rebecca Montgomery<sup>1</sup>; <sup>1</sup> University of Minnesota; <sup>2</sup> Minnesota Department of Natural Resources*

Garlic Mustard (*Alliaria petiolata*) is an invasive biennial forb of forest understories threatening native spring ephemerals and tree seedlings. Because it is a weed of sensitive forest ecosystems, chemical treatments are not ideal, and two imported biological control agents are currently prioritized as a potential management option for

*A. petiolata*. Pre-release monitoring of *A. petiolata* populations can help establish baseline information about the site-specific population dynamics of the weed and inform agent release efficacy. In June of 2018 and 2019, belt transects were used to monitor *A. petiolata* populations at four Minnesota locations. First year plants and second year stem density of *A. petiolata* was surveyed at each site. Here, plant-stage transition and density data collected from these transects are used to parameterize a coupled weed-herbivore model to run simulations of the population dynamics between garlic mustard and the proposed biological control agents: the rosette crown-miner, *Ceutorhynchus scrobicollis*, and the seed-feeder *Ceutorhynchus constrictus*.

### **Global Genetic Diversity in Hydrilla (*Hydrilla verticillata*) and Evidence for a Novel Invasive Strain in North America**

Nicholas Tippery<sup>1</sup>, Lori Benoit<sup>2</sup>, Donald Les<sup>2</sup>, Gregory Bugbee<sup>3</sup>, Summer Stebbins<sup>3, 1</sup> University of Wisconsin - Whitewater; <sup>2</sup> University of Connecticut; <sup>3</sup> Connecticut Agricultural Experiment Station

*Hydrilla* is one of the most notorious aquatic weeds in North America, where two widespread and ecologically different biotypes have largely separate ranges. Using novel molecular data from the nuclear internal transcribed spacer (ITS) region and phytoene desaturase (PDS) gene, we corroborated prior evidence that the monoecious and dioecious biotypes are genetically distinct and originated from different portions of the *hydrilla* native range. Nuclear data also provided evidence for hybridization in the native range among populations that otherwise have distinct plastid haplotypes. Both biotypes underwent hybridization before being introduced to North America. Additionally, molecular evidence identified a third biotype, recently introduced to New England from the northern portion of the native range. Our molecular characterization of *hydrilla* populations confirms the existence of three *hydrilla* biotypes in North America, each of which may present unique ecological challenges and require distinct management approaches.

### **Improvements to Drone Technology for Effective Pest and Noxious Weed Management**

Curtis Olsen<sup>1</sup>, Kerry Sun<sup>1</sup>, Inchara Laksmiaryan<sup>1</sup>, Eric Yu<sup>2</sup>, Domo Gebre-Egziabher<sup>1, 1</sup> University of Minnesota; <sup>2</sup> Minnesota Department of Agriculture

Unmanned Aerial Vehicles (or drones) have the potential of being effective tools in scouting and managing the eradication of the invasive plant and pest species. In the last few years the technology needed to enable the use of UAVs in this role has improved dramatically. However, many challenges still remain which have to be addressed before UAVs become an off-the-shelf (or "turn key") tool for scouting and management of invasive plant and pest species. In this presentation, we discuss two projects at the University of Minnesota UAV laboratory aimed at developing and improving the technology needed to effectively detect and map noxious weeds. We discuss how technology gaps can be filled with in-house developed open-source hardware and software tools. In particular, we describe an in-house autopilot system optimized to fly accurate survey patterns and a fixed-wing aerial platform capable of carrying a high-quality mirrorless camera. This allows us to achieve higher resolution, better pixel quality, and much longer flights compared to common off the shelf solutions. We also show how our in-house image stitching and mapping tools were optimized to better handle difficult high density tree areas and low level repetitive crop scenarios, again achieving much better results than typical commercial tools for the specific use cases that we encountered.

## **Invasive Species and Citizen Science Initiatives while Social Distancing**

*Angela Gupta; University of Minnesota Extension*

The University of Minnesota Extension is a state leader in citizen science and invasive species education. For many reasons the spring of 2020 was going to launch several new citizen science and invasive species projects; and then the world shifted because of COVID-19. Thankfully, all these projects could be done while also social distancing. This poster will outline the basic citizen scientist questions and protocols used for each invasive species project and offer a short overview of the projects including: Squill Hunt; Jumping worms: Report Management; Gender Bending Trees: Amur Corktree; Stop Oak Wilt; and Naturalized Norway Maple. Each project has a different audience, objective and tools that uniquely fit each question. Learn what worked; what didn't; and what we still don't know.

## **Invasive Species Signage Anyone?**

*Anna Peterson <sup>1</sup>, Doug Jensen <sup>1</sup>, Christopher Filstrup <sup>2</sup>; <sup>1</sup> Minnesota SeaGrant; <sup>2</sup> Natural Resources Research Center*

Northeast Minnesota waters are mostly aquatic invasive species (AIS)-free. Economic benefits of fisheries, wilderness, tourism and recreation suggest that protecting this region, including the BWCAW, from spread of AIS (e.g., zebra mussels, Eurasian watermilfoil, spiny waterflea) is in the public good. For three decades, Minnesota Sea Grant, Department of Natural Resources, and others have advocated for and used signs at public water and trailhead accesses as tools to protect our waters. Signage use is justified because Sea Grant-led surveys continue to show that access signs are the top source of information for recreationalists who use our waterways.

Regionally over time, several AIS sign types, sizes, and messages have been posted by various agencies and organizations. However, these efforts were not coordinated. So, where are those signs? Are they out-of-date? Missing? In need of replacement? To answer these questions, an AIS public water access and BWCAW portage trailhead access sign inventory was initiated as a collaborative effort by Rainy-Lake of the Woods Watershed, Natural Resources Research Institute, Minnesota Sea Grant, BWCAW Coalition, North St. Louis and Lake County Soil and Water Conservation Districts (SWCD). Sea Grant and SWCD interns visited public accesses to gather information on sign presence, type, size, message, and condition. Data will be: 1) analyzed to reveal potential patterns of AIS distribution, and 2) used to improve sign effectiveness across the region, aimed to promote actions to help Stop Aquatic Hitchhikers! Importantly, this effort serves as a model for effective expansion of AIS signage inventory to other regions.

## **Investments in Invasive Species Management by Municipalities and Conservation Authorities in Ontario**

*Sarah Rang <sup>1</sup>, David Nisbet <sup>1</sup>, Richard Vyn <sup>2</sup>; <sup>1</sup> Invasive Species Centre; <sup>2</sup> University of Guelph*

The Invasive Species Centre calculates that Ontario municipalities and conservation authorities spend an estimated \$50 million per year on invasive species management. The cost is felt most in urban areas, where expenditures are estimated at over \$1 million annually per municipality. When surveyed, invasive species managers in Ontario municipalities and conservation authorities indicated that emerald ash borer continues to be the costliest species. Other notable species include zebra and quagga mussels, gypsy moth, and invasive plants such as Phragmites and wild parsnip, which combined cost almost \$20M across Ontario to manage. About 80% of investments were at the management stage, with 20% at the prevention stage, often the most cost effective time for invasive species actions. Management expenditures by municipalities and conservation authorities on invasive species are just a fraction of the total economic impact and do not include substantial federal, provincial, and private expenditures. The potential impacts on agriculture, fisheries, forests, healthcare, tourism, and the recreation industry from invasive species are estimated to be \$3.6 billion per year in Ontario.



This work was done in partnership with the Regional Public Works Commissioners of Ontario and the Ontario Ministry of Natural Resources and Forestry.

### **Multi-agency Cooperation in Managing Garlic Mustard within the Northwoods Cooperative Weed Management Area**

*Ramona Shackelford; Northwoods Cooperative Weed Management Area*

The Northwoods Cooperative Weed Management Area (NCWMA) spans the northern four counties of Wisconsin (Ashland, Bayfield, Douglas, and Iron Counties). Garlic mustard (*Alliaria petiolata*) is a priority species for the NCWMA due to its ability to spread quickly into high quality forest habitats. The NCWMA organizes hand-pulling events each spring at most sites of garlic mustard in the region. Events include participation by school and volunteer groups as well as NCWMA partners. Two large infestations follow floodplains and have been hand-pulled annually through a multi-agency effort since their discoveries. The Bad River floodplain has over 150 acres of garlic mustard, of which 70 acres have been hand-pulled annually since 2008. Hand-pulling garlic mustard on the downstream areas of the infestation has been the focus to prevent its spread into Copper Falls State Park and the Bad River Indian Reservation. Herbicide treatments have been made occasionally in the fall within this same 70 acres. Garlic mustard along the Montreal River has been treated since 2011 and spans over 40 acres. Hand-pulling has focused on 14 acres on the western side of the Montreal River in Wisconsin. On the eastern side of the Montreal River in Michigan, herbicide treatments have been the primary management technique. Permanent monitoring plots were set in 2013 in both large infestations. Plots have found that the garlic mustard persists throughout the original targeted areas, but the density throughout the areas has decreased and native plant diversity has been maintained in areas with hand-pulling.

### **Native Pine Engravers Avoid Pheromones of Mountain Pine Beetle**

*Zach Smith, Aubree Kees, Brian Aukema; University of Minnesota*

Mountain pine beetle (*Dendroctonus ponderosae* Hopkins) (MPB) is an aggressive bark beetle native to western North America and the Black Hills of South Dakota. Given conducive conditions such as abundant host supply and low overwintering mortality, MPB populations can build up to epidemic levels and cause landscape-level mortality of mature pines. Due to ameliorating winter temperatures recent years have seen range expansion of MPB over the geoclimatic barrier of the Rocky Mountains in Alberta, Canada into stands of lodgepole pine (*Pinus contorta* Douglas) X jack pine (*Pinus banksiana* Lamb.) hybrids. Thus, there is emerging concern that MPB could use jack pine forest as a bridge to invade the Great Lakes Region. While MPB can colonize and reproduce within cut logs of all species of pine in the Great Lakes Region little is known about how it would interact with species of bark beetles with which it has no historic association. Such interactions could facilitate, inhibit, or have no effect on population dynamics. This study investigates species interactions between MPB and the native, non-aggressive bark beetle, *Ips grandicollis* Eichhoff. We found that MPB aggregation pheromones inhibit colonization and reproductive behavior of *I. grandicollis* in cut logs of jack pine. These results suggest that *I. grandicollis* will not be a significant competitor of MPB if it were to invade the Great Lakes region.

### **Predicting Range Expansion of Invasive Species: Obtaining Biologically Realistic Projections**

*Thomas Lake; University of Minnesota*

Species distribution models (SDMs) are commonly used to forecast invasions for early detection and eradication efforts. However, developing accurate SDMs for invasive species has historically been challenging for multiple reasons. First, occurrence data are often biased due to differences in species reporting effort (e.g. park surveys), recurrent eradication programs, and intensive sampling procedures (e.g. BioBlitz programs), which leads to a

record of known species locations that does not fully reflect the true biological pattern of species presence and abundance. Second, most SDMs assume the prevalence (ratio of sampled sites to sites containing the species) is constant throughout a species' range, which is untrue when sampling effort is uneven between established and incipient regions. To address these challenges, we tested bias-correction measures using a factorial design aimed at producing biologically-realistic SDMs. We developed SDMs for seven terrestrial invasive plants found throughout the Upper Midwest: Common Tansy (*Tanacetum vulgare*), Wild Parsnip (*Pastinaca sativa*), Common Teasel (*Dipsacus fullonum*), Brown Knapweed (*Centaurea jacea*), Black Swallowwort (*Vincetoxicum nigrum*), Dalmatian Toadflax (*Linaria dalmatica*), and Leafy Spurge (*Euphorbia virgata*). We found that models without bias correction exhibited the highest performance, but that these models were often overly complex, and predictions did not generalize well. Conversely, models that employed some form of bias correction were less complex and effectively balanced model performance, transferability, and complexity. We recommend that researchers interested in developing and implementing SDMs for invasive species for predictions of habitat suitability should thoroughly explore occurrence bias correction measures to build and select more biologically-realistic SDMs.

### **Prioritizing Minnesota's Top Terrestrial Invasive Plants & Pests for Research**

*Rob Venette and Amy Morey; University of Minnesota*

The Minnesota Invasive Terrestrial Plants & Pests Center at the University of Minnesota was established by the Minnesota legislature to support research that prevents or reduces harm from terrestrial invasive species (TIS). To prioritize the most pressing research needs for funding, MITPPC applied an Analytic Hierarchy Process (AHP) - a general method developed by decision scientists - to conduct a fair, consistent and transparent evaluation of 168 species. This approach followed five general steps: (1) selecting species for evaluation; (2) selecting criteria by which to compare species and determining the relative importance of those criteria; (3) establishing consistent measurement standards for each criterion; (4) reviewing information sources to assign a rating to each criterion; (5) analyze the results to determine a relative ranking for each species. New species may be added to the prioritization, and prioritizations of previously evaluated species may be adjusted as new information becomes available. The 15 highest rated invasive plants, plant pathogens and invertebrate animals (45 taxa or taxonomic groups in total) are eligible for research funding from MITPPC. Clear priorities have helped to promote cross-disciplinary research teams and engagement with external implementation partners.

### **Ratings of Invasive Species of Concern to Minnesota**

*Laura Van Riper<sup>1</sup>, Missy Anderson<sup>2</sup>, Jennifer Burington<sup>3</sup>, Megan Weber<sup>3</sup>; <sup>1</sup> Minnesota Department of Natural Resources; <sup>2</sup> Three Rivers Park District; <sup>3</sup> University of Minnesota Extension*

The Minnesota Invasive Species Advisory Council (MISAC) led an effort to compile lists of invasive species of concern to Minnesota to create an extensive list covering multiple taxa. The seven taxa categories are aquatic animals, aquatic microbes, aquatic plants, terrestrial animals, terrestrial insects, terrestrial pathogens, and terrestrial plants. Taxa teams compiled existing lists of problematic or potentially problematic invasive species developed for Minnesota or the Midwest. For each species it was noted if the species was present in Minnesota as of 2019, its risk of spread, its level of potential threat to human health, the physical environment, ecological impacts, economies, and infrastructure, as well as the difficulty of management. The final lists describe 230 invasive species present in Minnesota, 103 invasive species present but not established in Minnesota, and 268 invasive species not known to be present in Minnesota, but of concern to Minnesota. These lists do not identify all the invasive species that occur, or could occur, in the state. These are educational and informational lists shared on the MISAC website that can be used by managers, policy makers, researchers, and other interested parties.

## **Reporting Northeast Minnesota Aquatic Invasive Species Sightings**

*Alyssa Hagemeyer<sup>1</sup>, Doug Jensen<sup>1</sup>, Josh Dumke<sup>2</sup>; <sup>1</sup> Minnesota SeaGrant; <sup>2</sup> Natural Resources Research Institute*

Understanding where aquatic invasive species (AIS) are present is important for knowing their distribution, extent of potential impacts, and management. Across Northeastern Minnesota entities such as federal agencies, counties, and lake associations are conducting field work for early detection and monitoring of AIS. Some field work may be non-invasive in nature, so sightings of AIS can become buried in field notes and never formally reported, or potential sightings remain unverified. Verified AIS sightings may also be reported among multiple databases, which can cause at least temporary differences in the distribution of AIS presence information.

Aquatic invasive species like banded mystery snail (*Viviparus georgianus*), Chinese mystery snail (*Cipangopaludina chinensis*), curly-leaf pondweed (*Potamogeton crispus*), and rusty crayfish (*Orconectes rusticus*) are of interest, but are often underreported. We requested sighting locations of these species from resource agencies (government and non-government organizations) in St. Louis, Lake, Itasca, Carlton, and Cook Counties. We then compiled that information into an updated infested waters list to show the extent and pattern of spread in Northeastern Minnesota. This project was led by Minnesota Sea Grant in collaboration with the 1854 Treaty Authority and UMD Natural Resources Research Institute.

## **Spotlight on ISM Track**

*Mari Hardel<sup>1</sup>, Monika Chandler<sup>1</sup>, Christina Basch<sup>1</sup>, Anne Pearce<sup>2</sup>, Bob Dunning<sup>3</sup>, Chuck Barger<sup>4</sup>; <sup>1</sup> Minnesota Department of Agriculture; <sup>2</sup> Wisconsin First Detectors Network; <sup>3</sup> Stearns County, Minnesota; <sup>4</sup> University of Georgia*

Do you manage invasive species? Do you collaborate with others? Do you use EDDMapS? Then get ready for the Invasive Species Management Tracking system, or ISM Track! This program has been in development between Minnesota, Wisconsin and developers at the University of Georgia and consists of a web accessible platform and mobile app for use in the field. Users create sites, or areas of management, link EDDMapS reports to the sites, and then enter management information. This system allows data to be stored in a central location and accessed by management partners then compared from year-to-year. The mobile version of ISM track helps users navigate to sites using Google Maps and allows users to record data in real time as management happens - including photos, weather information, chemical use, and other important information. This tool is great for projects with contractors or anyone looking to keep data more organized and easily accessible to those who need to query treatment information.

## **Using DNA Tools to Elucidate Source of Dreissena to Western Lake Superior**

*Jonathan Barge, Chelsea Hatzenbuehler, Anne Cotter, Joel Hoffman, Christy Meredith, Greg Peterson, Sara Okum, Erik Pilgrim, Barry Weichman, Anett Trebitz; U.S. Environmental Protection Agency*

Dreissena mussels have been established in the St. Louis River (SLR), the largest tributary to Lake Superior since 1989. Dreissena are readily transported via ballast water and boat hull attachment, so their lack of establishment in Lake Superior was thought due to inhospitable physiochemical conditions. That notion was challenged by recent Dreissena finds in the Apostle Islands (APIS) region located ~100 km east of the SLR. Motivated by concerns surrounding these finds, the U.S. EPA in 2017 conducted an intensive survey of APIS waters (100 sites, DNA & traditional sampling methods) aimed at understanding Dreissena prevalence and distribution. We did not find any settled Dreissena but did find low densities of planktonic veligers at 44% of sites and detected Dreissena DNA in biofilm collected from passive samplers. Since these finds were primarily on the western side of APIS and the SLR is the only substantial Dreissena population in the region, we wondered whether these veligers were spawned within APIS or transported there from the SLR by long-shore currents. We

followed up in 2019 with a study designed to assess this possibility by examining changes in veliger detections, densities, and size along the SLR to APIS gradient. This effort consisted of 8 locations where we sampled plankton and eDNA, each collected 3 times 2 weeks apart, and deployed passive samplers for the duration of the survey. All samples were tested for *Dreissena* DNA using qPCR. This poster will summarize findings from the 2017 effort and present results from the 2019 effort.