BUILDING ON THE MIDWEST LEGACY OF RESTORATION: LINKING THEORY AND PRACTICE

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ABSTRACT BOOK – DRAFT 3/12/2014

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KEYNOTE PRESENTATION

Galatowitsch, Susan*. **Hit-and-run restoration.** University of Minnesota, St. Paul, Minnesota. Email: galat001@umn.edu

Over the past few decades, people have attempted with confidence larger and more complex ecological restoration projects. This is good news because restoration is trivial unless pursued at a scale and scope commensurate with the Earth's most pressing environmental challenges. However, as a scientific field and as a professional practice, ecological restoration has not made much progress towards working at meaningful time-scales. In many parts of the world, restoration efforts under a few years in duration abound, whereas projects with ongoing management and monitoring exceeding 5 years are rare. For the most part, this short project time horizon reflects policy preferences for funding new projects and program budget cycles tied to short-term accountability. Short time horizons are not consistent with the recovery rates of ecosystems, which we have learned is often much longer than expected. And, for highly degraded ecosystems, there is mounting evidence that restoration interventions must be sustained long enough to counteract the reinforcing effects from positive feedbacks – or risk project failure, To restore highly degraded grasslands, wetlands, rivers, or forests is clearly a commitment of decades, not a couple of years. What can be done to reduce the prevalence of "hit-and-run" restorations? First, plans and budgets need to be tied to realistic, time-bound goals. Second, competitive funding for restoration work should be based on an organization's demonstrated ability to achieve ecological outcomes and to rebound after setbacks and surprises. Third, researchers need to focus attention on providing decision-support for follow-up restoration actions and on developing restoration methods intended to accelerate recovery. Finally, policy should balance financial support for both new and ongoing restoration efforts.

OPENING PLENARY SESSION ABSTRACTS

INTERDISCIPLINARY INSIGHTS FOR GUIDING FUTURE ECOLOGICAL RESTORATION AND SUSTAINABILITY EFFORTS

Apfelbaum, Steven I.* **Forty years of attempting to bridge the developing science and practice of ecological restoration.** Applied Ecological Services, Inc., Brodhead, Wisconsin. Email: steve@appliedeco.com

Ecological restoration as a field of science and as an on-the-ground practice has developed rapidly in recent years. In the 1970's when I was a student at the University of Illinois there were field courses focused on teaching taxonomy, field ecology, mensuration methods, but not restoration. My alma mater was no different than other universities in that ecosystem restoration was not the focus of research, education, or any training opportunities. If you wanted to learn about forest management, wildlife management, or agriculture - you received training in planning and implementing on-the-ground land management decisions and practices. Some of these traditional techniques can guide current ecological restoration efforts, but their intent is focused on producing board feet, more deer or pheasants, or improving corn yields. Successfully conceptualizing, designing, and implementing ecological restoration projects requires an eclectic training through formal course work and on-the-ground experience. In my personal experience, the on-the-ground experience studying remnant natural areas and remote wilderness areas has provided a greater foundation in understanding how the composition, structure, and dynamics of biotic communities respond to perturbations or disturbances than formal academic training. I will share how my traditional formal training in science has been recast and molded by field experiences on thousands of projects around the world and used to obtain information capable of guiding future ecological restoration efforts. My involvement in a wide range of projects has taught me that nature always throws curve balls when stasis is most often desired in policy, political and land management programs.

Weiher, Evan. **On the relevance of theory to restoration science and practice.** University of Wisconsin – Eau Claire, Eau Claire, Wisconsin. Email: weiher@uwec.edu

Linking theory to practice in ecological restoration is superficially easy, but it is actually a daunting challenge. Just a few years ago, an ecologist reviewed the degree to which ecologists make a clear reference to theory within their peer review publications, and the degree to which the published science was intended to test fundamental theory in ecology. The rates of clear references to theory within the scientific literature were surprisingly low. These rates are no doubt even lower in applied ecology and restoration ecology. Is this really a problem? To what degree is the success of a restoration project (or even experiment) predicated on making use of ecological theory? I suspect the answer is little to none. I further suspect that this is because restoration practitioners are more like chefs and other craftsmen than engineers and ecologists are more like economists than physicists. I also suggest that the gap between restoration practitioners and theory-minded ecologists is largely a matter of aesthetics, arbitrary privilege, and reward structures. I do believe that theory-minded ecologists have a lot to gain by collaborating with restoration practitioners, but a great challenge to these types of collaborations is the need for control plots and other ugly experimental impediments. I also feel insights from the recent explosion of scientific findings related to novel aspects of biodiversity will provide valuable information for the practice of ecological restoration. Specifically, information on functional and phylogenetic diversity within and among plots can inform us on which communities can or should be restored and can be used in developing restoration targets for future restoration projects.

Larkin, Daniel J. **Investigating restoration actions and outcomes: what happens if we turn this dial?** Chicago Botanic Garden, Glencoe, Illinois. Email: dlarkin@chicagobotanic.org

The value of restoration practice is clear when we see a once-degraded site transformed into a diverse, well-functioning ecosystem. This form of "intelligent tinkering" is of obvious importance for conservation. But what is the value of the science of studying restoration, i.e., the systematic observation and investigation of intelligent tinkering? A key contribution of restoration ecology to ecological restoration is, in its most basic form, a framework for answering the question, "If we turn this dial, what happens?" In other words, is the system sensitive to a given manipulation? Does it respond in a desired way? The science of restoration can provide insights into what dials to turn and where to look to see if a needle has moved, and it can help organize collective learning about restoration actions and their consequences. I illustrate these different aspects of restoration science with three ongoing research projects that my students, collaborators, and I are conducting. In a 'dial-turning' study, we are investigating phylogenetic diversity—drawing more broadly from across the "Tree of Life" in selecting plant species for restoration—as a heuristic for restoring communities with high functional diversity. In a 'needle-moving' study, we are testing how diverse communities of native, mostly solitary bees respond to grassland restoration. We are drawing on the power of 'collective learning' in our project PhragNet, in which we are investigating the effectiveness of different management actions for controlling invasive *Phragmites australis* through a large-scale, research-management collaboration.

Shaw, Daniel. **Using ecological theories to improve restoration success**. Minnesota Board of Water and Soil Resources, St. Paul, Minnesota. Email: dan.shaw@state.mn.us

Minnesota has a diversity of plant communities with prairie potholes to the south, coniferous forests and bogs to the north, and savannas and deciduous forest in central and eastern portions of the state. There is also a strong history of partnerships and the sharing of information between agencies, universities, and conservation groups to restore landscapes and further the field of ecological restoration. Ecological theories and supporting research related to landscape connectivity, diversity, succession, ecological function, and resiliency play an important role in defining the components of a successful and ecologically complete restoration effort, and are used as a foundation for the development of program goals and plans for the Minnesota Board of Water and Soil Resources. Technical resources such as seed source guidelines, regional seed mixes, and restoration guidance also help provide a framework that combined with practitioner experience guide the development of specific goals and decision making for individual projects. The way we think about and apply ecological theories and research findings change over time as we gain information about project success or failure through research partnerships, a "Practitioners Network", a "What's Working" webpage, and restoration evaluations that are all used to collect information from across the state and make it available to professionals. This information is essential for program staff to update or adapt program goals, planning, and technical resources as needed with the ultimate goal of improving the success of future restoration efforts.

SYMPOSIA AND WORKSHOP ABSTRACTS

COMMERCIAL USES FOR PRAIRIE VEGETATION SYMPOSIUM ABSTRACT

Jackson, Laura L. **Finding commercial uses for prairie vegetation in agricultural watersheds**. University of Northern Iowa Tallgrass Prairie Center, Cedar Falls, Iowa. Email: laura.jackson@uni.edu

Globally significant regions of agricultural production such as the Midwestern United States face interconnected challenges such as the loss of biodiversity, soil loss, soil degradation, nutrient pollution leading to widespread marine hypoxic zones, hydrological alteration resulting in greater risk of flooding, and increased vulnerability to drought. There is emerging consensus that climate change may not only significantly reduce crop yields, but it will also undermine the long term capacity of terrestrial and aquatic ecosystems to recover from extreme climate events. Field studies, watershed-scale modeling, and historical analyses have converged on a common solution to meaningfully address these interconnected problems -- increasing perennial vegetative cover on the landscape. While scientific evidence for these approaches is well established, and the methods are largely known, market and policy incentives are currently much stronger to grow corn and soybeans. In order to shift socioeconomic drivers towards more sustainable farming systems, it will be necessary to demonstrate economically viable models, and provide training and support for landowners. Several research teams in Midwestern United States are currently exploring the agronomic methods and market mechanisms to capitalize on the ecosystem products and services provided by perennial vegetation. This symposium will present the results of these efforts in the area of feed and fodder, biomass energy, and native seed production, and explore how these interdisciplinary research results can contribute to regional restoration on a landscape scale.

COMMERCIAL USES FOR PRAIRIE VEGETATION SYMPOSIUM PRESENTATION ABSTRACTS

Jackson, Laura L.* **Finding commercial uses for prairie in agricultural watersheds: a review of the possibilities, and what it will take to get us there**. University of Northern Iowa Tallgrass Prairie Center, Cedar Falls, Iowa. Email: laura.jackson@uni.edu

In order for diverse, perennial vegetation to expand in the former prairie region, it will be necessary to find economic uses that can compete with current annual row crop. Uses for perennial vegetation include forage, grazing, biomass energy, seed production, perennial grain crops, and mixed annual/perennial cropping systems. The goal of raising native prairie vegetation on farms for income will require several advancements: in new products, agronomy and cropping systems, livestock nutrition and husbandry, and innovations in the capture and efficient use of low-quality energy sources. Beyond the mechanics of the products themselves there are other challenges. Considerable effort must be devoted to the creating novel value chains, identifying and recruiting early adopters, and building systems of mutual support. This process will be able to learn something from the (re) development of local/regional food markets and the rise of the organic food industry. Public policy which promotes climate change resilience through improvement of common property resources (soil quality and watershed health) and ecosystem services will be necessary as well. I review several possibilities for commercialization of diverse, perennial herbaceous systems (both native and non-native). Agricultural ecosystems of the future will need to produce food and support rural communities while maintaining fertility and biological diversity in an unpredictable and rapidly changing climate.

Jarchow, Meghann[1]*, Matt Liebman[2], David Sundberg[2], Virginia Nichols[2], Shashi Dhungel[3], Robert Anex[3], and Ranae Dietzel[2]. **Ecological and agronomic tradeoffs in prairies managed with nitrogen fertilization.** [1]University of South Dakota, Vermillion, South Dakota. [1]Iowa State University, Ames, Iowa. [3]University of Wisconsin, Madison, Wisconsin. Email: Meghann.Jarchow@usd.edu

Prairies are the native ecosystem for most of the central US but have largely been converted to annual row crops. Cellulosic bioenergy production provides an opportunity to reincorporate prairies into agriculturally dominated landscapes, yet how the prairies are managed affects their ecological and agronomic performance. As part of a 9-ha field experiment that was established in 2008 in Boone County, IA, we compared the performance of two prairie systems – one receiving spring nitrogen fertilization at a rate of 84 kg N ha^{-1} yr^{-1} and one without fertilization – managed with fall mowing and subsequent biomass removal. We evaluated four performance indicators: aboveground biomass, root biomass, plant diversity, and net energy balance (NEB). We found tradeoffs between the prairies in terms of the measured performance indicators. Aboveground biomass was higher in the fertilized prairie than the unfertilized prairie averaging 10.4 Mg ha^{-1} yr^{-1} and 7.4 Mg ha^{-1} yr^{-1}, respectively, between 2009 and 2013. Root biomass, on the other hand, was higher in the unfertilized prairie than the fertilized prairie averaging 7.5 Mg ha^{-1} and 4.0 Mg ha^{-1}, respectively, between 2008 and 2012. Diversity was initially higher in the unfertilized prairie (2009 and 2010), but became higher in the fertilized prairie in subsequent years (2011 and 2013) due to increasing dominance by warm-season grasses in the unfertilized prairie. The estimated NEBs of the unfertilized and fertilized prairies were similar at 10.53 GJ ha^{-1} and 11.40 GJ ha^{-1}, respectively, but were more variable in the fertilized prairie due to greater variability in harvestable yields. We found that both unfertilized and fertilized prairies managed for bioenergy production can produce a substantial amount of biomass, have similar diversity to other restored prairies, and have favorable NEBs, but that nitrogen fertilization has strong effects on biomass allocation and plant community composition.

Mary A. Harris[1]*, Lisa A. Schulte[1], Matthew J. Helmers[1], J. Gordon Arbuckle[1], Pauline Drobney[2], Randall K. Kolka[3], Matt Liebman[1], Matthew E. O'Neal[1], John C. Tyndall[1]. **Prairie strips integrated with row crops: biodiversity, soil conservation and income opportunities.** [1]Iowa State University, Ames, Iowa. [2]U.S. Fish and Wildlife Service, Prairie City, Iowa. [3]USDA Forest Service, Grand Rapids, Minnesota. Email: maharris@iastate.edu

With much of the U.S. Midwest in agricultural production and under private ownership, any viable conservation practice must fit within the context of currently profitable production systems. We study the ability of strategically integrated "prairie strips"—contour buffer and filter strips composed of diverse, native, perennial plants—to achieve this. We hypothesize that the conversion of small amounts of row-cropped watersheds to native prairie can provide environmental quality and conservation benefits that are disproportionately greater than expected based on the land area converted. We have been testing this hypothesis since 2007 at the Strategic Trials of Row crops Integrated with Prairies (STRIPs) research and demonstration site, a replicated watershed experiment at Neal Smith National Wildlife Refuge in central Iowa, USA. We have found that prairie strips comprising 10-20% of no-till corn-bean agricultural catchments reduce sediment transport by 95%, total phosphorus and nitrogen transport by 90%, and surface water flow by 60% compared to catchments entirely in no-till corn-bean agriculture. These results are consistent across a range of weather conditions, including high-rainfall and drought years. Prairie strips also provide habitat for native plants, insect pollinators and natural enemies, and birds, including some species of greatest conservation need. Financial analysis of the practice reveals that depending upon total area covered by strips relative to the whole field, the annualized present value costs of using prairie strips can be as little as $59 to $87 per treated ha/yr. We are beginning to explore avenues of revenue associated with the adoption of the STRIPs practice such as biomass harvest, grazing, honey production and ecosystem service provision credits.

Johnson, W. Carter. **Profitable prairie restoration: the EcoSun Prairie Farm experiment.** South Dakota State University, Brookings, South Dakota. Email: carter.johnson@sdstate.edu

The environmental benefits of prairie to soil, water, and biota are beyond question. The economic potential of restored prairie on former cropland, however, had not been explored in the Western Corn Belt at the whole farm scale until EcoSun Prairie Farms, Inc. established its South Dakota project in 2008. The 6-year experiment has shown that prairie farming on relatively small farms (~500 acres) is profitable through the sale of native plant seed, hay, and grass-fed beef. A profit of approximately $60,000 was reached by year 3 and remained relatively steady afterwards despite extreme weather ranging from drought to deluge. Labor and land costs were not included in the economic analysis, so net returns represent returns to owned land and operator labor. More study of potential income streams for a prairie farm is needed, such as ecotourism, education, biofuel potential, carbon credits and fee hunting; however, the results of the experiment thus far are encouraging that grain in this region is not the only farming option, especially for conservation-minded land owners on smaller farms who desire a low input, perennial crop system and all of its environmental—and now proven economic—advantages.

BLACK ASH WETLAND RESTORATION SYMPOSIUM ABSTRACT

Lenhart, Christian[1], Anthony D'Amato[1], and Robert Slesak[1,2]. **Consequences of emerald ash borer induced mortality for black ash wetlands: Insights from research for restoration and management.** [1]University of Minnesota, St. Paul, Minnesota. [2]Minnesota Forest Resources Council, St. Paul, Minnesota. CL Email: lenh0010@umn.edu; AD Email: damato@umn.edu; RS Email: raslesak@umn.edu

Black ash-dominated wetlands are abundant in the Upper Great Lakes and northeastern portions of North America, covering 4047 km^2 in the state of Minnesota alone. The impending loss of forested ash wetlands across this region due to the emerald ash borer (EAB) raises difficult questions for management and restoration of these ecosystems. Black ash (*Fraxinus nigra*) often constitutes the primary tree species in these wetlands and only a few non-host tree species are capable of filling its ecological niche following EAB infestation. Little is known about the ecology of black ash wetlands despite the prevalence of this wetland type across the region. For example, the hydrologic response of widespread ash mortality is unknown. It is thought that widespread tree death would increase water levels as a result of reduced transpiration and interception. Similarly, the recruitment and vegetation dynamics of these wetlands are largely unknown hampering efforts aimed at encouraging the regeneration of non-host species within these forested wetlands. Our symposium will discuss the ecological setting in which forested ash wetlands occur and potential ecological and hydrological responses to EAB-induced mortality. Results from a large-scale, manipulative experiment in northern Minnesota evaluating the implications of EAB for restoration and management will be presented. Detailed studies of the dynamics of old-growth black ash wetlands will also be included to provide a broader ecological context for restoration activities in the face of EAB. These studies also provide an excellent example of the integration of scientific theory and practical forest management and restoration. Lessons learned from the ecological and hydrological studies presented as part of this symposium will provide valuable insights and guidance for forested ash wetland restoration efforts throughout the Great Lakes region.

BLACK ASH SYMPOSIUM PRESENTATION ABSTRACTS

D'Amato, Anthony W.[1]*, Brian J. Palik[2], Rob A. Slesak[3], Christian F. Lenhart[1]. **Overview of a large-scale experiment to assess the impacts of emerald ash borer on the structure and function of black ash forest ecosystems and the potential for restoration.** [1]University of Minnesota, St. Paul, Minnesota. [2]USDA Forest Service, Grand Rapids, Minnesota. [3]Minnesota Forest Resources Council, St. Paul, Minnesota. [1]University of Minnesota, St. Paul, Minnesota. Email: damato@umn.edu

Black ash (*Fraxinus nigra*)-dominated wetland forests cover a large proportion (> 600,000 ha) of the upper Great Lakes region and provide many cultural and ecological values. Nonetheless, little is known about the dynamics of these forests or the restoration opportunities that may exist for increasing their resilience to the impacts of the introduced emerald ash borer (EAB). We established a large-scale (> 20 ha) manipulative experiment in a series of black ash-dominated wetlands on the Chippewa National Forest, Minnesota to evaluate the impacts of EAB and pre-emptive restoration strategies on the hydrology and vegetation of these systems. Treatments included: 1) control, 2) girdling of all black ash trees in 1.6 ha areas to simulate EAB mortality, 3) group selection harvests (20% of stand in 0.04 ha gaps), and 4) clear-cut harvest of 1.6 ha areas replicated eight times. Seedlings of 11 different non-host tree species, including *Thuja occidentalis*, *Ulmus americana*, *Larix laricina*, and *Quercus bicolor*, were planted across each of these treatments to evaluate their potential as replacement species in these ecosystems following EAB infestation. Natural baseline conditions for these forests are being established through a companion project documenting the natural dynamics of old-growth black ash forests across the region. Dendroecological data from these areas indicate that natural age structures for these forests are strongly uneven-aged with overstory black ash ranging in age from 220-314 years old. In addition, natural disturbance patterns in these areas rarely exceed 5% of the canopy area per decade highlighting the importance of maintaining overstory canopy cover during restoration plantings. These baseline findings and the results of our manipulative study will be used to inform restoration strategies to minimize the impacts of EAB on these highly vulnerable ecosystems.

Lenhart, Christian*[1], Mark Davidson[1], Robert Slesak[1,2], Ken Brooks[1], Anthony D'Amato[1], and Andrew Telander[1]. **The hydrologic setting of black ash wetlands: implications for restoration and management.** [1]University of Minnesota, St. Paul, Minnesota, [2]Minnesota Forest Resources Council, St. Paul, Minnesota. Email: lenh0010@umn.edu

The spread of emerald ash borer threatens to alter the hydrology of black ash wetlands across the upper Midwest through widespread ash mortality. Yet little is known about their hydrologic characteristics. Black ash wetlands are palustrine (inland) wetlands found throughout glaciated portions of the Midwest and northeastern U.S. A hydrologic study was initiated in 2011 to measure the hydrologic response of ash wetlands in northern Minnesota to experimental treatments simulating death from ash borer. To better understand the response we researched the sources of water to the wetlands, flow paths and the potential consequences for restoration and management. Our study sites were located primarily on lacustrine clays or dense glacial tills that promote surface ponding. We placed monitoring wells in 32 locations within the experimental cuttings and control plots. Dataloggers recorded water table depth from 2011-2013. Net rainfall input was measured using interception gages and tree transpiration estimated with sap flux probes. Water sources and pathways were examined using water geochemical and isotopic data with hydrologic gradient information. Most wetland plots had pooled surface water from April to June with drawdown of 1-2 m occurring throughout the summer to the point of dryness in many sites. Ground water-surface water interactions were very dynamic with multiple "flooding" events occurring per year. Specific conductivity and Oxygen and Hydrogen isotopes showed that water in the wetlands originated primarily from rainfall and localized surface runoff in the spring. Lateral groundwater flow occurred in the topsoil above the impermeable clay layer. Low interception and transpiration in black ash could minimize long-term hydrologic changes

relative to other wetland types. Yet in the short term, there will likely be ecological shifts and possible infrastructure issues. Since few trees are adopted to the hydrologic conditions found in these wetlands it is unclear which tree species could replace ash.

Looney, Christopher E.[1]*, Anthony W. D'Amato[1], Brian J. Palik[2]. **Effects of potential emerald ash borer mitigation strategies on natural regeneration and herbaceous communities in northern Minnesota black ash wetlands.** [1]University of Minnesota, St. Paul, Minnesota. [2]USDA Forest Service, Grand Rapids, Minnesota. Email: loone016@umn.edu

Black ash (*Fraxinus nigra*) is an integral component of wetland forests in the upper Great Lakes region. Despite the expansiveness of black ash-dominated wetlands, these forests have been of low economic value in terms of timber harvesting, yet support high plant species diversity. Black ash appears highly suited to the seasonally flooded sites it presently dominates, and the prospects for natural regeneration of potential replacement tree species following emerald ash borer (*Agrilus planipennis*, EAB)-related mortality or preemptive management activities are largely unknown. Management experience to date suggests that sudden loss of black ash overstories may result in prolonged increases in site moisture, impeding restoration efforts following either EAB-induced mortality or preemptive salvage logging. We examined the response of natural woody regeneration and the herbaceous layer community under several potential EAB-mitigation treatments in northern Minnesota. Treatments included simulated EAB-induced-mortality (girdling), clearcutting, and a group selection harvest intended to promote tree regeneration while less dramatically altering moisture and light levels. Preliminary results suggest that short-term (2 yr) effects of clearcutting in black ash wetlands may result in increased dominance of sedges and other moisture-adapted, herbaceous species. These effects were not yet apparent in girdled areas, where overstory ash did not senesce until 2 yr post-treatment. In group selection treatments, harvesting did not result in a dramatic response of herbaceous species adapted to high site moisture. Woody regeneration was dominated by resprouting species, including black ash, in both harvesting treatments. Our results will inform land managers of the relative reliability of natural regeneration, as well as broader community responses that may impact effectiveness of restoration, under several post-EAB mitigation strategies.

Reinikainen, Mike[1*], Anthony W. D'Amato[2], Brian J. Palik[3], Rob A. Slesak[4], and Christian F. Lenhart[2]. **Two-year survival of potential replacement tree species in ash-dominated wetlands.** [1]Cloquet Forestry Center, Cloquet, Minnesota. [2]University of Minnesota, St. Paul, Minnesota. [3]USDA Forest Service, Grand Rapids, Minnesota. [4]Minnesota Forest Resources Council, St. Paul, Minnesota. Email: rein0331@umn.edu

Minnesota's wet ash forests contain overstory, subcanopy, and regeneration layers dominated by black ash (*Fraxinus nigra*) and a variety of companion species present in low abundance. The monotypic nature of this forest type makes it susceptible to wide-spread mortality following emerald ash borer (*Agrilus planipennis*; EAB) infestation. Managers interested in maintaining tree cover and associated ecological services following EAB arrival are employing management strategies aimed at enhancing resilience by increasing species diversity of non-host trees. Unfortunately, little information exists concerning the conditions necessary for the establishment, growth, and survival of typical companion species in these systems. To bridge these knowledge gaps, we evaluated the survival of potential replacement species in the aforementioned large scale manipulative study. Study treatments included two mitigative harvest treatments (clear-cut and group selection harvest), a simulation of overstory decline following EAB infestation (girdle), and a control. Treatments were planted with twelve species: *Acer rubrum*, *Betula alleghaniensis*, *Celtis occidentalis*, *Fraxinus mandshurica, Larix laricina, Picea mariana*, *Populus balsamifera*, *P. deltoides, P. tremuloides, Quercus bicolor, Thuja*

occidentalis, and *Ulmus americana*. To evaluate the effects of planting season, half of the seedlings were planted pre-treatment (fall 2011) and half were planted post-treatment (spring 2012). Seedlings censuses occurred at the end of the first (2012) and second (2013) growing seasons. Survival was nearly identical for spring and fall plantings (38% and 40%, respectively), but was significantly lower for all species in the clear-cut (31%) compared to the control (40%), girdle (43%), and group selection (43%) treatment. Survivorship was > 60% for *F. mandshurica, Q. bicolor, C. occidentalis, and P. balsamifera*. Survival was greatest in the control and girdle treatment for Q. bicolor. These findings can be incorporated into future forest management efforts where the objectives are to increase overstory diversity and resilience of wet ash forests to the effects of EAB.

Slesak, Robert A.[1,2,*], Ken Brooks[1], Anthony D'Amato[1], Christian Lenhart[1], and Brian Palik[3]. **Water table response of black ash wetlands to simulated emerald ash borer mortality and harvesting.** [1]University of Minnesota, St. Paul, Minnesota; [2]Minnesota Forest Resources Council, St. Paul, Minnesota. [3] USFS Northern Research Station, Grand Rapids, Minnesota. Email: raslesak@umn.edu

Black ash (*Fraxinus nigra*) wetlands and the ecosystem services they provide are seriously threatened because of the invasive emerald ash borer (EAB). Wetland hydrology is likely to be modified following ash mortality, but the magnitude of alteration following its loss via EAB or preemptive harvesting is not clear. Girdling (to simulate EAB mortality), forest harvest type (clear cut or 20% removal with group selection), and control treatments were replicated in northern Minnesota and water table (WT) response was measured for two years. There was little effect of girdling on the WT in the first year post-treatment, but the WT was elevated throughout the second year when canopy dieback was prevalent, resulting in a significant increase in the number of days when it was within 30 cm of the soil surface. Harvest treatments also increased the WT height compared to control treatments, with the effect more pronounced in the clear cut compared to the group selection treatment. Harvest effects were generally limited to periods when the WT was below 30 cm depth. WT responses were attributed to the influence of treatment on vegetation establishment and increased evaporation, which were lowest in the girdling treatment due to the presence of a partial overstory canopy. Given the large influence of WT depth on vegetation dynamics and hydrologic feedbacks, these early results indicate a greater risk of ecosystem alteration following EAB mortality compared to harvesting. Depending on local hydrologic regime, variation in precipitation patterns, and time for complete canopy loss, it may be necessary for managers to implement active mitigation strategies prior to EAB infestation to maintain ecosystem processes in these wetland systems. In these instances, the group selection treatment appears to be a viable strategy to convert stand composition while minimizing the risk of hydrologic alteration.

MINNESOTA'S WATERSHED RESTORATION AND PROTECTION PROGRAM SYMPOSIUM ABSTRACT

Klucas, Chris[1], Pat Conrad[2], Jason Naber[2], Meghan Jacobson[2], and Casey Thiel[3]. **Minnesota's state-wide watershed restoration and protection program – putting the Clean Water Act into action.** [1]Minnesota Pollution Control Agency, St. Paul, Minnesota. [2]Emmons & Olivier Resources Inc., Oakdale, Minnesota. [3]Chisago Soil and Water Conservation District, North Branch, Minnesota. CL Email: Christopher.Klucas@state.mn.us; PC Email: pconrad@eorinc.com; JN Email: jnaber@eorinc.com; MJ Email: mjacobson@eorinc.com; CT Email: casey.thiel@mn.nacdnet.net

The State of Minnesota has recently adopted a watershed approach to address the water quality of its 81 major watersheds. This watershed approach incorporates water quality assessment, watershed analysis, civic engagement, planning, implementation, and measurement of results into a 10-year cycle

that addresses both restoration and protection of lakes and streams. In addition to listing waters not meeting state standards as impaired and performing Total Maximum Daily studies, the watershed approach process facilitates a more cost-effective and comprehensive characterization of multiple water bodies and overall watershed health. A key aspect of this effort is to develop and use watershed-scale models and other tools to help state agencies, local governments, and other watershed stakeholders determine how to best proceed with restoring and protecting lakes and streams. In this symposium, five representatives from two public agencies and a private consulting firm will share their knowledge of and experiences with the new watershed approach. The symposium will provide: 1) a state agency perspective of the WRAPS (watershed restoration and protection strategy) process; 2) an independent consulting firm perspective of the technical challenges associated with watershed-wide restoration, such as lake water quality modeling, stream bacteria source identification, and stream aquatic life stressor identification; and 3) a county agency example of how the WRAPS process translates into real-world restoration and protection activities. The symposium will end with a question and answer session providing an opportunity for the research and restoration community to ask questions about the Watershed Restoration and Protection Strategy approach, to provide input on how their research and restoration activities may benefit this process, and to ultimately shed light on key water quality questions that need to be addressed by the research community to further advance state-wide water quality restoration and protection projects.

MINNESOTA'S WATERSHED RESTORATION AND PROTECTION PROGRAM SYMPOSIUM SYMPOSIUM PRESENTATION ABSTRACTS

Klucas, Chris. **An overview of the Watershed Restoration and Protection strategy process.**
Minnesota Pollution Control Agency, St. Paul, Minnesota. Email: Christopher.Klucas@state.mn.us

The Minnesota Pollution Control Agency (MPCA) adopted a watershed approach to restoring and protecting Minnesota's rivers, lakes, and wetlands in 2008, as recommended by the Clean Water Council, directed by the Minnesota Legislature, and predominantly funded by the Minnesota Clean Water Fund established in 2008. The cyclical watershed approach allows efficient and effective use of public resources in addressing water quality challenges across the state. Concentrating efforts at the major watershed scale ensures: a) an ongoing, predictable cycle for water quality management and evaluation; b) a more efficient approach for addressing water quality impairments; c) a common framework for monitoring, assessments, setting required pollutant reductions, and implementation strategies; and d) improved collaboration and innovation. Repeating the management process every 10 years allows periodic measurement of outcomes, identification of new problems, and refinement of strategies and investments. The water quality management cycles for the 81 major watersheds are staggered, with 8 to 10 watersheds beginning a new cycle each year. By 2017, all watersheds will have at least begun their first cycle, and those that began in 2008 will enter their next cycle. This monitoring and assessment data lays the groundwork for a Watershed Restoration and Protection Strategy (WRAPS) report, a comprehensive document that: a) summarizes scientific studies of the watershed, including the physical, chemical, and biological assessment of the water quality of the watershed; b) identifies impairments and water bodies in need of protection; c) identifies biotic stressors and sources of pollution (both point and nonpoint); and d) includes an implementation table which contains strategies and actions designed to achieve and maintain water quality standards and goals. Hear from MPCA about recent developments and challenges with the WRAPS process and in progress or completed examples from around the State.

Jacobson, Meghan. **Modeling lake water quality and internal phosphorus loads.** Emmons & Olivier Resources, Inc., Oakdale, Minnesota. Email: mjacobson@eorinc.com

Lake water quality modeling is a critical first step for establishing phosphorus loading reductions needed to meet lake water quality goals. A common, complicating factor in developing lake models is determining the amount of internal phosphorus loading – the result of excessive, usually long-term, sources of phosphorus from the watershed that are stored in and recycled from lake sediments. Lake models require good estimates of internal loading to properly guide restoration and protection activities, especially in shallow lakes where the majority of the phosphorus loading driving poor water quality is internal. Hear more from Emmons & Olivier Resources about how internal loads are estimated for input to lake water quality modeling programs, such as BATHTUB, and how internal loading can be reduced through lake management activities, such as whole lake drawdowns, chemical alum treatments, and in-lake food web management.

Conrad, Pat. **Identifying stream bacteria sources and reduction strategies.** Emmons & Olivier Resources, Inc., Oakdale, Minnesota. Email: pconrad@eorinc.com

All surface waters in Minnesota, including lakes, rivers, streams, and wetlands, are protected for aquatic recreation where feasible. Aquatic recreational uses of our surface waters are associated with a specific numeric water quality standard for bacteria that reduces the risk of illness from this pollutant in water. Although most are harmless themselves, fecal indicator bacteria are used as an easy-to-measure surrogate to evaluate the microbiological suitability of recreational and drinking waters, specifically, the presence of pathogens. Humans, pets, livestock, and wildlife contribute bacteria to the environment, where they can survive for long periods in sand and sediments. These bacteria, after appearing in fecal material, are dispersed throughout the environment by an array of natural and man-made mechanisms. Bacteria fate and transport is affected by, for example, human waste disposal and treatment mechanisms, methods of manure reuse, imperviousness of land surfaces, and natural decay and die-off due to environmental factors such as UV exposure and detention time in the landscape. It is the complexity of these fate and transport mechanisms that make it particularly difficult to decipher and quantify bacteria loading sources. In response to the complex problem of identifying bacteria sources in the watershed, Emmons & Olivier Resources (EOR) has developed a three pronged GIS-based approach that: 1) estimates the total amount of bacteria produced by the animal and human populations, 2) determines the fraction of bacteria that leaves a site in runoff, and 3) models the probability of bacteria in runoff being transported to downstream surface waters. Hear more from EOR about identifying watershed bacteria sources and which watershed best management practices can be used to reduce the transport of bacteria to lakes and streams.

Naber, Jason. **Linking stream aquatic life impairments to pollutant- and habitat-based stressors.** Emmons & Olivier Resources, Inc., Oakdale, Minnesota. Email: jnaber@eorinc.com

Is your stream stressed? Identifying factors that harm fish and other stream life is a key part of the watershed restoration and protection projects being carried out by the Minnesota Pollution Control Agency (MPCA) under Minnesota's Clean Water Legacy Amendment. The MPCA works in several streams throughout Minnesota each year to gauge stream health. Many streams suffer from stressors that harm fish and other aquatic life. These stressors may also affect recreation such as swimming and fishing. The MPCA and local partners examine many interrelated factors to identify stressors: a) stream connections, such as dams, culverts and tile drainage; b) hydrology, including stream flow and runoff; c) stream biology, such as fish and bugs; d) water chemistry, including oxygen levels, nutrient levels and temperature; and e) stream channel assessment, including erosion. The goal is to maintain

conditions in healthy streams and fix problems in unhealthy streams. Learn more about the stressor identification process from Emmons & Olivier Resource's current work in the Nemadji River Watershed near Duluth, Minnesota.

Thiel, Casey. **Putting the restoration and protection plan into action through civic engagement, grant writing, and project implementation.** Chisago Soil and Water Conservation District, North Branch, Minnesota. Email: casey.thiel@mn.nacdnet.net

The Clean Water Legacy Act (CWLA) requires that WRAPS reports summarize priority areas for targeting actions to improve water quality and identify sources of pollution with sufficient specificity to prioritize and geographically locate watershed restoration and protection actions. In addition, the CWLA requires including an implementation table of strategies and actions that are capable of cumulatively achieving needed pollution load reductions for point and nonpoint sources. Because most nonpoint source reduction strategies rely on voluntary implementation by landowners, land users and residents of the watershed, it is imperative to create social capital (trust, networks and positive relationships) with those who will be needed to voluntarily implement best management practices. Local Soil & Water Conservation Districts are taking lead roles in these WRAPS civic engagement and implementation efforts. Learn more from the Chisago SWCD about how the WRAPS process translates into real-world restoration and protection implementation activities, from planning to construction.

PRAIRIE SEEDLING IDENTIFICATION WORKSHOP ABSTRACT

Williams, Dave W. **Seedling identification of selected prairie plants.** Tallgrass Prairie Center, Cedar Falls, Iowa. Email: dave.williams@uni.edu

Prairie restoration often involves the introduction of desired plants by seed. Assessing plant establishment success or failure in the first and second growing seasons is critical for determining appropriate management action. In order to conduct an accurate assessment of plant establishment, the resource manager or landowner must have the skills necessary to identify native forbs and grasses as seedlings and juveniles. This workshop will use live seedling plants to give participants a "hands on" experience and the confidence to identify seedling plants commonly found in the tallgrass prairie in the Midwestern United States. Participants will identify a few basic plant parts, find those parts on live plants, and learn about key characteristic groups to help identify prairie seedlings. In addition, there will be selected look-alike weed seedlings available for comparison. Everything is provided in this workshop. All that is needed is the desire to enjoy the experience and to come prepared to get your hands dirty and take home seedling prairie plants at the end of the workshop.

JOINT PLENARY SESSION PRESENTATION ABSTRACTS

RESTORATION SCALED-UP: AMBITIOUS SOLUTIONS TO COMPLEX CHALLENGES IN MINNESOTA AND BEYOND

Cornett, Meredith W.* **Supersize me: approaches to large-scale restoration in a changing world.** The Nature Conservancy in Minnesota, North Dakota and South Dakota, Duluth, Minnesota. Email: mcornett@tnc.org

In recent years, large-scale restoration has gained momentum in the conservation community. The need to "scale up" restoration projects is often referenced as a pathway to bolstering resilience, sustaining ecosystem services and restoring connectivity. To determine whether a large-scale approach is appropriate requires clarity about restoration objectives, timeline, and desired changes. The success of large-scale projects also depends on defining the scaling strategies at the outset. I will explore emerging approaches to "scaling up " by highlighting two contrasting examples of The Nature Conservancy's large-scale restoration projects: 1) The Glacial Ridge Project (9,000 ha), initiated in 2001, is the largest prairie wetland restoration in North America; and 2) Adaptation Forestry in Minnesota's Northwoods, a project supported by the Wildlife Conservation Society's Climate Adaptation Fund, was initiated in 2012. Both projects were implemented in conjunction with numerous state, federal, and local partners. In terms of habitat and ecological objectives, the two projects differ significantly. The Glacial Ridge Project, conducted over a 10-year period, aimed primarily to reconnect fragmented tallgrass prairie habitat and restore hyrologic function to address spring flooding in the Red River Valley. In contrast, the more recent Adaptation Forestry project is underway in the relatively unfragmented sub-boreal forests of northeastern Minnesota with an overall goal of enhancing resilience in the face of climate change. The area directly impacted by the Adaptation Forestry project is smaller than that of Glacial Ridge (<1,000 ha), but the project is ultimately intended to impact >2.4 million ha in northeastern Minnesota. Generalizable considerations for designing projects to impact increasingly large spatial and temporal scales will be summarized.

Magner, Joseph* **WRAPS: Minnesota's Codified Watershed Restoration Program.** University of Minnesota and Minnesota Pollution Control Agency, St. Paul, Minnesota. Email: magne027@umn.edu

The 2013 Minnesota Legislature created a law requiring the state environmental agencies to produce watershed restoration and protection strategies (WRAPS) for each major (8-digit HUC) watershed. Northern Minnesota is the protection oriented part of the state, whereas the intensively managed Red River Valley and southern portions of the state will focus on restoration. Though restoration is needed over much of the agricultural landscape to meet water quality standards, implementation of a given restoration plan will be difficult to achieve without one-on-one farmer conversations. Funding from the Clean Water Legacy will typically pass through a local unit of government to landowners. However, landowner "buy-in" will require good science and persuasive arguments to demonstrate win-win opportunities. Scientists from the University of Minnesota have been engaged with local government and landowners in the Elm Creek watershed near the Iowa border for over a decade. Wetland and stream restoration has been limited, but we have observed small incremental changes in water storage, nutrient sequestration, habitat and biota. Over the next two decades, with funding from the Clean Water Legacy, Minnesota citizens expect to see restored streams that meet or exceed water quality standards.

Lee, Jeffrey* **Minneapolis Chain of Lakes Clean Water Partnership.** Barr Engineering Company, Duluth, Minnesota. Email: jefflee@barr.com

The Chain of Lakes Clean Water Partnership was a 10-year initiative that in the beginning was one of the largest urban lake restoration projects in the nation. The Minneapolis Chain of Lakes Clean Water Partnership project focused on developing and implementing a plan for improving and preserving four lakes: Cedar Lake, Lake of the Isles, Lake Calhoun, and Lake Harriet. It was funded by the Minnehaha Creek Watershed District, Minneapolis Parks and Recreation Board, City of St. Louis Park, Hennepin County, City of Minneapolis and the Minnesota Pollution Control Agency. The Minneapolis Chain of Lakes are located 4.8 km southwest of downtown Minneapolis, Minnesota. The chain's five lakes are the central natural resource feature of the Minneapolis Chain of Lakes Regional Park. The chain receives urban runoff from a fully developed 32 km^2 watershed that includes portions of Minneapolis and the adjoining suburban communities. Major land use categories within the watershed include residential development (51%), industrial/commercial (19%), and open space (14%). A critical part of the management plan was the development of lake water quality goals and watershed loading reductions strategies by a Citizens Advisory Committee. The long-term goals recommended by the Committee were based upon an analysis of historical, existing lake conditions, and predicted lake conditions. A short-term target of 10 to 20 percent pollutant reduction for all water quality management activities, and a long-term target of pollutant reduction of greater than 20 percent in selected watersheds is the goal. The results of the $12 million project (using $1.1 million in state funding) are improved water quality and a healthy, sustainable environment for recreation on and around these important lakes.

ORAL PRESENTATION ABSTRACTS (ALPHABETIC)

Aadland, Luther *. **Spatial and temporal scales of river restoration effects**. Minnesota Department of Natural Resources, Fergus Falls, Minnesota. Email: luther.aadland@state.mn.us

Rivers have been fragmented and degraded in term of hydrology, rates of erosion and sedimentation, water quality and biodiversity. Biodiversity is dependent on all of these changes and the extinction rates of freshwater species are estimated to be five times that of terrestrial species. Many different types of restoration projects have proposed and built including habitat structures, bank stabilization, re-establishment of riparian zones, floodplain reconnection and re-meandering of channelized streams, dam removal, and fish passage. The limitations of funding for stream restoration dictate the need to evaluate scales of benefit for restoration types. Depending on the project, benefits may extend spatially to reach, sub-watershed, watershed, or basin scales. Benefits may last years, decades, or centuries depending on whether they deteriorate or re-establish self-sustaining processes. Examples of projects affecting a range of scales will be presented and discussed.

Anderson, Roger C.[1]*, M. Rebecca Anderson[1], Erica A. Corbett[2]. **Weevils, deer, and fire effects on flowering diversity of tallgrass prairie forbs.** [1]Illinois State University, Normal, Illinois. [2]Southeastern Oklahoma State University, Durant, Oklahoma. Email: rcander@ilstu.edu

Our study revealed a complex interaction of deer browsing, a prairie endemic weevil (*Haplorhynchites aeneus*), and fire on production of flowering stems by prairie forbs. Our study site included two plots protected from deer browsing and two unprotected plots. The study was conducted over a four-year period (1998-2001) and the plots were burned twice (1999 and 2001) in late April. The total number of flowering stems was significantly higher on protected plots than unprotected plots in non-burned years. However, in burn years there was no significant difference in number of flowering stems between protected and unprotected plots due to a significant increase in flowering stems of *Silphium integrifolium* (Rosinweed), the leading species on unprotected plots. The increase in Rosinweed flowering stems in burn years resulted from fire eliminating the prairie weevil that partially clips peduncles of Rosinweed flowering heads. The two leading species on protected plots (*Helianthus mollis,* Ashy Sunflower, and *Veronicastrum virginicum*, Culver's Root) tended to have significantly fewer flowering stems during years of burning than in years without burning and always had significantly fewer flowering stems in unprotected than protected plots. For the second leading species on the unprotected plots, *Parthenium integrifolium* (Wild Quinine), there was no significant difference in the number of flowering stems on protected and unprotected plots; however, burn years had significantly more flowering stems than non-burn years for this species. Diversity (Shannon Index H') of flowering stems was significantly higher on protected than on unprotected plots for all years of the study.

Bajer, Przemyslaw G.* and Peter W. Sorensen. **The role of common carp in phosphorus cycling, water clarity and vegetation density in a stratified eutrophic lake: a whole lake experiment.** University of Minnesota, St. Paul, Minnesota. Email: bajer003@umn.edu

Although numerous studies have investigated the role of common carp (*Cyprinus carpio*) in nutrient cycling, water clarity, and vegetation density, few attempted whole lake manipulations, and none were conducted in thermally stratified lakes. In this study we documented changes in total phosphorus, water clarity, and aquatic vegetation in a stratified eutrophic lake where we reduced the biomass of carp from 300 kg/ha to 40 kg/ha. Carp removal was associated with an increase in littoral aquatic vegetation, an increase in springtime water clarity, a decline in early season chlorophyll a and a decline

in total suspended solids. However, neither clarity nor chlorophyll a improved during summer months. The removal of carp had no effect on total phosphorus, which increased rapidly in the summer both before and after carp removal driven by abiotic internal loading. The lack of phosphorus decline following carp removal suggested that despite their high biomass, carp played a relatively minor role in nutrient transport from benthic sediments into the water column. While several factors might explain why the role of carp in phosphorus cycling in Lake Susan was less than previously demonstrated in shallow lakes, we suggest additional whole lake manipulations to address the role of this species in nutrient cycling using ecologically relevant scales.

Ballantyne, Drew M.*, Scott Witte, and John P. Maksymiu. **Golf's environmental opportunities**. Cantigny Golf, Wheaton, Illinois. Email: drewbtyne@live.com

The amount of natural areas and greenspace is decreasing due to increased population and development. However, with increased efforts, golf courses can offer additional habitat for wildlife and other ecosystem services. There are approximately 16,000 golf courses in the United States, and the greenspace they provide offers great opportunities to enhance our environment. Cantigny Golf, which is located just west of Chicago, is one of the earliest golf courses to become certified in the Audubon Cooperative Sanctuary Program for Golf Courses. This program addresses six main categories: environmental planning, wildlife and habitat management, chemical use reduction & safety, water conservation, water quality management, and education/outreach. Cantigny is taking large steps in all six categories. Cantigny has both short-term and long-term goals to stay on leading edge of environmental awareness, responsibility, and activism. Cantigny conducts prescribed burns, invasive species control and management, streambank stabilization, habitat management, water conservation via effluent water use and rainwater harvesting, and many other activities. Over the past 25 years, Cantigny has conserved over one billion gallons of freshwater reserves by utilizing effluent and rain water sources. Cantigny has explored and utilized cutting edge technology for healthy pond and aquatic management via sonic solution devices, aeration units, and various biological agents. Cantigny Golf continues to expand its environmental programs through initiatives like the Cantigny Golf bee barometer project. Cantigny also continues to create more native areas within the golf course boundaries. Through Cantigny's outreach and education programs, they have been able to assist the Awutu-Winton Senior High Bee Club in Ghana, Africa as well other neighboring golf courses by assisting them starting their own bee hives.

Bassett, Tyler*. **Land use legacies in prairie restoration: persistent effects on invasion resistance.** Michigan State University, East Lansing, Michigan. Email: basset17@msu.edu

A primary challenge of restoration is preventing the proliferation of invasive exotic species. The long-term goal is restoring stable communities with properties that naturally resist invasion. Previous work suggests that more diverse communities are more stable and better able to resist invasion. The diversity-invasibility hypothesis suggests that biotic interactions are strong regulators of invasion success, and more diverse restorations will better resist invasion. Native and exotic diversity is often positively correlated in natural communities, however, at least at broad scales across which important environmental drivers vary. Therefore, the effects of diversity may vary with or even be overwhelmed by abiotic variation. In 2011, and 2013, I surveyed plant community composition in 29 established prairie reconstructions in soutwest Michigan (sown with between 8 and 71 species) to test for the effect of diversity (seed mix richness, native plant species richness, and the richness of sown species) on exotic species abundance and richness. I also tested whether several environmental factors (abiotic soil factors, spatial characteristics, landscape factors, site history, and vegetative structure) altered the diversity-invasibility relationship. In 2011, I found that higher diversity was generally correlated with

lower exotic species abundance, but this effect was only evident in models including key environmental drivers, notably land use history and litter. Invasive exotics were especially sensitive to land use history. Non-invasive exotics on the other hand, were often positively correlated with diversity, and only when controlling for different factors, notably soil characteristics. The pattern was similar in 2013, although the effect of diversity was largely absent, while legacies from historical land use persisted. This change may be a consequence of lower exotic abundances overall in 2013. However, it may suggest two things: 1) the importance of diversity decreases over time, and 2) land use legacies do not.

Bohnen, Julia L.* and Susan M. Galatowitsch. **Using monitoring data to guide management decisions at the Spring Peeper Meadow wetland restoration**. University of Minnesota, St. Paul, Minnesota. Email: bohne001@umn.edu

Biological and environmental data gathered during restoration monitoring should inform ongoing management decisions. However, restoration monitoring and management are seldom linked. Often a monitoring protocol is conceived to document the ecological recovery of a habitat and the data may be very complex. In addition, the individuals gathering the data may not communicate with the site manager. Spring Peeper Meadow (SPM) provides a model for how monitoring data can be used to make management decisions. Restored in 1997, SPM has been intensively monitored for the 17 years since its restoration. Floristic cover data has been collected every 4 to 5 years in 26 permanent large plots arranged along an environmental (hydrological) gradient. Although very detailed, the floristic cover data gathered can be gleaned to provide guidance on daily management decisions. A quick graphical summary of select data can provide a picture of both management successes and challenges, from the extent of dominant native species to the extent and general distribution of invasive species along the hydrologic gradient. The graphical representation of floristic cover data combined with surface hydrology data and permanent photo point images, can be used by restoration managers to assess how hydrology may be influencing the establishment of species, and will enable them to make short term decisions such as which species to manage aggressively and where to focus their management efforts. When data can be quickly summarized in a way that is easy to grasp it is more likely to be used to make management decisions. Detailed records and data can also be used to provide an accurate historical context for management actions, ensuring that the history of the restoration is not trusted to the memory of the site manager, but rather is recorded and available for reference by future managers as well.

Boote, Martin J.* and Greg L. Gaulke. **Evaluating fish movement following dam removal.** Environmental Consulting & Technology, Inc., Ann Arbor, Michigan. E-mail: mboote@ectinc.com

The Great Lakes Restoration Initiative (GLRI) created important restoration opportunities throughout the Great Lakes Basin. Perhaps more importantly GLRI invoked a new era of accountability predicated on demonstrated restoration success through effective monitoring. The availability of funding for monitoring restoration projects was previously limited and insufficient. The National Oceanic & Atmospheric Administration (NOAA) provided a GLRI grant to the Berrien County Brownfield Redevelopment Authority (BRA) to remove two dams on the Paw Paw River in 2010. The two primary purposes of dam removal are often fish passage and stream restoration. The theoretical premise is that removal of a dam will restore unrestricted fish movement and natural fish community composition. Due a common lack of funding for monitoring dam removal projects these premises have rarely been directly tested through fish capture. We used both direct and indirect measures of fish passage to evaluate restoration of free fish movement following removal of two dams on the Paw Paw River in Berrien County, Michigan. Indirect measures included flow velocity and jump height

measurements before and after dam removal. Direct measurement of passage was accomplished using a simple mark-recapture study. Target fish were marked by clipping the anal fin for later recapture. This technique increases the probability of capturing marked fish over 50 miles of river at a relatively low cost versus more advanced techniques such as telemetry. Fish community changes were also studied in an abandoned historic channel using diversity indices and a t-test for the Shannon-Wiener Diversity Index. Sampling and data analysis showed a statistically significant change in the fish community of the historic channel from a warm-water, lentic assemblage to a cool-water, lotic assemblage. Use of multiple fish community indices proved useful for describing and fully characterizing the fish community changes that proved to be significant.

Cornett, Meredith W.* **Palms, pines, and people: redefining forest restoration in the Anthropocene.** University of Minnesota, Saint Paul, Minnesota. Email: corn0043@umn.edu

The daily, individual activities of humans pack a collective punch. What we have wrought—climate change, hypoxia zones, atmospheric deposition—serves as a reminder that people are by definition part of nature, whether we know it, like it, or not. Today's conservation movement in the United States is increasingly concerned with the relationships between people and nature. A handful of prominent voices within the conservation community have named Earth's current epoch the Anthropocene – the age of man. This view has incited an impassioned debate that has all the makings of a paradigm shift for conservation. "Neo-conservationists" dismiss classical conservation as too fixated on the illusion of pristine wilderness and advocate a broadened view of today's nature, whether it manifests within a national park or an abandoned city lot. In response, "traditionalists" charge Neo-conservation with accepting the loss of biodiversity—as long as ecosystems can continue to provide services to humans. How does this parley play out for restorationists? Since our field's emergence in the 1980s, ecological restoration by definition has beaten the drum of human intervention to reverse human-caused damage. In a certain way, Neo-conservation is pointing an approving finger right at us. Drawing on examples from two biomes—boreal systems of northern Minnesota and tropical dry forests of the Republic of Panama— this session will examine the seemingly conflicting roles of humans: agents of ecological degradation, creators of restoration solutions, and beneficiaries of nature's services. Although their timelines and pathways to degradation differ, the two geographies share some strikingly similar themes, which arise from tensions surrounding restoration practices, approaches to conservation, and the needs of humans living within and adjacent to public lands. This presentation highlights concepts from my new book *Heart of Palms: My Peace Corps Years in Tranquilla* (University of Alabama Press, 2014).

Di Misa, Joe*. **Great Lakes coastal ecological restoration challenges and successes at Middle Bass Island, Ohio.** Woolpert, Dayton, Ohio. Email: joe.dimisa@woolpert.com

The Ohio Department of Natural Resources (ODNR) recognized the great potential for Middle Bass Island State Park to meet several significant recreational needs and preserve a part of Ohio's unique natural and cultural heritage. Considering this overarching vision, ODNR's goal was to create a park that is accessible to all state residents and fill needs for boat slips, safe harbor, camping and day use. It was apparent from the outset of the planning process that unique ecological and cultural features of Middle Bass Island and its region make the park a special place. With the excavation of an expanded marina, new lake entrance channel, and landside development, a wide variety of ecological resources were affected requiring the largest ecological restoration effort ever undertaken by ODNR. These ecological restoration efforts included: restoration of Lake Erie Water Snake hibernacula, creation of 1.75 acres of vernal pool habitat, restoration of 0.30 acres of high quality coastal wetlands,

enhancement of a 0.93 acre high quality wetland including American lotus plantings, restoration of 1.83 acres of submerged aquatic vegetation beds, preservation and invasive species management of 7.73 acres of wetlands, and *Phragmites australis* control of 30.7 acres of island wetlands. This presentation will highlight the unique logistical challenges of island construction and selection of a pre-qualified design-build contractor. Further, weather challenges and water level fluctuations in the middle of Lake Erie, and the management of invasive species will be reviewed. The project has just completed its five year monitoring period, so the lessons learned from that period will be summarized. This presentation will be valuable to anyone considering ecological restoration in a remote, Great Lake island location.

Dreisilker, Kurt M.[1]*, Jeffrey Dawson[2], and Andrew Koeser[3]. **Enhancing establishment of white oak and American hazelnut enrichment plants in a mesic forest using understory removal and group selection.** [1]The Morton Arboretum, Lisle, Illinois. [2]University of Illinois at Urbana-Champaign, Urbana, Illinois. [3]University of Florida Gulf Coast Research and Education Center, Wimauma, Florida. Email: kdreisilker@mortonarb.org

In the absence of periodic disturbance, primarily fire, many oak-dominated woodlands in the Eastern and Midwestern United States are transitioning to sugar maple (*Acer saccharum*) dominated communities. This experiment was conducted to determine the effects of forest overstory and/or understory removals on enrichment plantings of white oak (*Quercus alba)* and American hazelnut (*Corylus americana)*. The combination of prescribed forest canopy openings and understory tree removal significantly increased mean twig elongation, an indicator of overall growth and vigor, of white oak as compared to control trees. A similar pattern was seen in the hazelnut, with the two treatments that included a group selection opening offering a significant growth advantage over the treatment which only included understory clearing. Group selection openings in this study were small (250 m^2) compared to previously recommended canopy openings of 1,000 m^2 or more, suggesting that oak and hazelnut regeneration may be enhanced without the dramatic visual impact of more intense silvicultural practices of clearcutting and shelterwood and when using large planting stock (> 1.5 m in height or 2.5 cm caliper for oak and 3-4 year old containerized hazelnut). As such, successful oak and hazelnut establishment and growth may be possible in intensively-managed, frequently-visited forest preserves where maintaining site aesthetics is a high priority.

Esser, Rebecca[*1], Jessica Dowler[2], Pauline Drobney[3], and Melinda Knutson[4]. **Making smart decisions about tallgrass prairie reconstruction.** [1]U.S. Fish and Wildlife Service, Detroit Lakes, Minnesota. [2] U.S. Fish and Wildlife Service, Erskine, Minnesota. [3]U.S. Fish and Wildlife Service, Prairie City, Iowa. [4]U.S. Fish and Wildlife Service, La Crosse, Wisconsin. Email: rebecca_esser@fws.gov

Prairie reconstruction (planting prairie) is a common practice among natural resource agencies and organizations and private individuals throughout the upper Midwest. However, many practitioners have important questions about the reconstruction process, which could have serious implications for the efficiency and success of their projects. These uncertainties inspired a one-week Structured Decision Making workshop held at Neal Smith National Wildlife Refuge in November 2012. Structured Decision Making (SDM) is a process that can help land managers systematically work through a complex problem to make the best possible management decisions. We identified prairie reconstruction uncertainties and discussed alternative approaches to address uncertainties including literature reviews, improved communication tactics, and applied research. At the close of the workshop, participants identified key questions that became the priority as we transitioned from the SDM framework into a collaborative working group. This working group, the Prairie Reconstruction

Initiative Advisory Team (PRIAT) consists of members from 11 private and public organizations and universities. PRIAT strives to discover if there are underlying common objectives that are the underpinnings of all reconstructions. Small groups are exploring five priority needs identified as critical to move forward: 1) develop a prairie literature database; 2) schedule field days at various locations to showcase prairie reconstruction efforts; 3) develop a tool to collect standardized information during the reconstruction process; 4) develop monitoring protocols to assess the success of prairie reconstructions; and 5) conduct a retrospective analysis of past prairie reconstructions. This is not a fast-paced initiative by any means. We continue the iterative process founded in the 2012 SDM workshop from our desks by utilizing information provided by the smaller groups to further refine our objectives. These "baby steps" are critical to pare down questions and promote a better understanding of prairie reconstruction.

Gillespie, Robert B.*[1], Peter C. Smiley Jr.[2], Kathryn E. Sanders[1], Kevin W. King[2], Douglas R. Smith[3], and Elizabeth A. Pappas[3]. **Restoration implications of the results from a tiered assessment conducted to evaluate the influence of water chemistry on fishes within agricultural headwater streams.** [1]Indiana University-Purdue University Fort Wayne, Fort Wayne, Indiana. [2]USDA Agricultural Research Service, Columbus, Ohio. [3]USDA Agricultural Research Service, West Lafayette, Indiana. Email: gillespi@ipfw.edu

Land use in regions of the Midwest is dominated by crop agriculture that depends on ditch drainage systems for maximum productivity. Many drainage networks comprise headwater streams that have been degraded by alteration of habitat and by introduction of agrichemicals. Understanding the relative impacts of agricultural contaminants and habitat degradation on aquatic biota within agricultural headwater streams will provide information that can assist with the restoration of these streams. Since 2006, we have conducted annual ecological assessments of fishes, water chemistry, instream habitat, and riparian habitat in seven channelized headwater streams in the Upper Big Walnut Creek Watershed of central Ohio and three channelized headwater streams in the Cedar Creek Watershed of northeastern Indiana. Additionally, streamside bioassays using fathead minnows (*Pimephales promelas*) were completed over a two-year period (2010-2011) at the Cedar Creek study sites. Biomarker surveys of three fish species were made at three channelized headwater stream sites and one reference site in both watersheds during 2011-2013. Fish community metrics were more strongly correlated with instream habitat than either riparian habitat or water chemistry. These same fish-habitat relationships occurred across watersheds. Results from bioassays and biomarker surveys suggested that fishes have not experienced significant negative health effects from exposure to contaminants in agricultural headwater streams. Analysis of water chemistry data showed that concentrations of agricultural contaminants, such as herbicides, nitrate, and ammonia were typically below those known from laboratory studies to cause chronic toxicity in fishes. In general, our results suggest that conservation practices and land-use practices targeted only to prevention of agrichemicals to receiving streams will not result in significant improvement of fish community integrity. Restoration projects that lead to improvements in physical habitat quality, however, should result in positive changes to fish communities within agricultural headwater streams in the Midwestern United States.

Hmielowski, Tracy L.*[1], Sarah K. Carter[2], Hannah Spaul[3], Volker Radeloff[2], Paul Zedler[2]. **Where should we burn? Techniques for identifying priority areas at landscape scale.** [1]Tallgrass Prairie and Oak Savanna Fire Science Consortium, Madison, Wisconsin. [2]University of Wisconsin - Madison, Madison, Wisconsin. [3]The Nature Conservancy, Madison, Wisconsin. Email: thmielowski.tpos.firescience@gmail.com

While there are well established methods for identifying priority areas for conservation, few take into account the effort and challenges of maintaining a site long term. The goal of our study was to develop a method for prioritization of land management activities, taking into account the benefit, effort, and feasibility of management activities. We present a case study prioritizing areas for management with prescribed fire in the state of Wisconsin, USA. We used publicly available nationwide datasets (e.g., LANDFIRE) to identify the existing community types dependent upon fire and to create indices of management effort (i.e., time and resources to apply prescribed fire), management benefits (i.e., maintaining conservation priority areas), and management feasibility (i.e., probability of successfully applying prescribed fire at a site). Using these indices, we highlight the greater effort required to maintain communities with frequent fire return intervals, and the special consideration involved in applying prescribed fire in the Wildland Urban Interface. We demonstrate how these indices can be combined mathematically into more comprehensive ranking criteria that vary based on planning objectives. We present three examples of the ranking criteria, (1) priority areas based on ecological fire needs, (2) priority areas for the greatest benefit with limited effort, and (3) areas with a high likelihood of long term management with prescribed fire. We also discuss how these methods can be adapted to highlight priority areas for restoration by quantifying the ecological benefits, effort, and feasibility of success.

Hoch, Greg*[1], and Rebecca Esser[2]. **A comparison of methods for surveying vegetation diversity in restored prairies.** [1]Minnesota Department of Natural Resources, Madelia, Minnesota. [2]U.S. Fish and Wildlife Service- Detroit Lakes Wetland Management District, Detroit Lakes, Minnesota. Email: greg.hoch@state.mn.us

Despite our best efforts, many of our restorations continue to have lower diversity than native prairie. One issue is that different survey methods yield different results. While no particular method is right or wrong, different methods may be best suited to different questions/hypotheses. We surveyed 22 restored prairies in the Red River Valley and south-central Minnesota. We used six different techniques including a random walk which is a more qualitative assessment, as well as transects and plots which are more quantitative. Transects and plots allow us to determine relative cover of species while random walks only allow us to determine species richness. We identified 80 species across all sites. Richness at each site ranged from 17 to 45 species, while species density at the $1m^2$ scale ranged from 0.7 to 6.8 species per meter. The plots and transects only sampled 55-60% of the species identified in the random walk. However, each method captured similar numbers of species at each site. A group of USFWS, USGS, TNC, and DNR researchers are currently examining these data in the context of future prairie plan monitoring activities.

Husveth, Jason J.* **Restoring rich fen and wet prairie peatlands using native seed banks in the Anoka Sand Plain, Minnesota**. Critical Connections Ecological Services, Inc., Scandia, Minnesota. Email: jhusveth@ccesinc.com

Rich fens and wet prairies were abundant native plant communities of the Anoka Sand Plain prior to European settlement in Minnesota. These plant communities comprised over ten percent of the land cover of this 1.1 million acre ecological subsection of Central Minnesota. Anoka Sand Plain rich fens

and wet prairies formed in shallow to deep peats within glacial melt water troughs, ice block depressions, and undulating bottoms of former Glacial Lake Fridley. Presettlement sand plain peatlands supported a diverse native flora, including many Eastern Coastal Plain disjuncts, which are now considered rare or extinct in Minnesota. Since European settlement, Anoka Sand Plain peatlands have declined in quality and quantity due to ditching, draining, agricultural conversion, development, altered hydroperiods and water chemistry, fire suppression, and competition from aggressive native and exotic plant species. However, many of these altered rich fen and wet prairie remnants still contain viable and diverse native seed banks that can be used to restore native plant communities and associated rare plant populations. Through applied field research at multiple project sites, Jason Husveth has developed methods and protocols to assess the viability and restoration potential of dormant peatland seedbanks, and to restore degraded sand plain wet prairie and rich fen plant communities. Using custom fabricated equipment along with more traditional restoration and management tools, Mr. Husveth has been able to reliably stimulate native seed banks lying dormant beneath densely accumulated saturated biomass. The results of these unique restoration efforts have led to the restoration of some of the most floristically diverse examples of wet prairies and rich fens in Minnesota.

Jessop, Jordan*, Jeffrey Matthews, Angela Kent, Thomas J. Benson, and Michael Ward. **Tradeoffs among ecosystem services in restored wetlands.** University of Illinois, Champaign-Urbana, Illinois. Email: Jordan@jessop.me

Recently restoration ecology and land management have found new focus and direction by emphasizing the value of ecosystem services to society. Resource management decisions frequently involve choices that reflect tradeoffs among ecosystem services. Tradeoffs occur when one service changes at the expense of another. These tradeoffs are not always explicit, and can exist without our knowledge. As a consequence, land managers may make decisions that diminish the value of some services while enhancing the value of others. Wetlands provide many ecosystem services, such as water quality maintenance, carbon storage, flood water abatement, and biodiversity support. Current compensatory wetland mitigation policy relies on the assumption that wetlands can be restored to provide a full suite of services. The goal of this study was to determine what tradeoffs exist among ecosystem services in restored wetlands, and identify the abiotic and biotic drivers underlying these tradeoffs. Thirty compensatory mitigation wetlands from across Illinois were included in this study. We measured denitrification potential, soil organic matter decomposition, aboveground herbaceous biomass, and soil organic content as proxies for nutrient-storage and removal services. Additionally, flood water storage potential was calculated using detailed LiDAR and topographic data. Since wetlands provide valuable biodiversity support, we determined plant, anuran, and avian diversity for each site. We found a clear tradeoff between biodiversity support and nutrient-cycling processes. Additionally, we found a positive relationship among the biodiversity indicators. Our findings indicate that designing wetlands to maximize nutrient storage and removal may likely come at the expense of biodiversity. Restoration policy makers and practitioners should consider these tradeoffs when planning wetland restoration and conservation at a watershed or landscape scale. Given these tradeoffs, it is unrealistic to expect all services to be maximized, therefore, restoration practitioners should prioritize services depending upon local site and watershed context.

Johnson, Douglas H.*, Lawrence D. Igl, and Brent E. Jamison. **Effects on breeding birds of seeding mixtures in planted grasslands.** U.S. Geological Survey, Jamestown, North Dakota. Email: douglas_h_johnson@usgs.gov

One benefit of restoring grasslands is providing habitat for grassland nesting birds, many of which have suffered serious population declines. One U.S. federal farm program, the Conservation Reserve Program (CRP), resulted in vast areas of cropland restored to grassland for 10 to 20 years or longer. Certain guidelines for CRP plantings encourage the use of native rather than introduced species. However, native plantings are significantly more expensive, and take longer to become established, than introduced plantings. It is therefore critical to understand if native plantings are worthwhile for restorations of limited duration. We studied breeding-bird use of CRP fields in five north-central states during 2001-2003, involving 128 fields planted either with primarily native or introduced species. Both planting types supported large populations of certain grassland bird species, such as Bobolink, Savannah Sparrow, and Grasshopper Sparrow. There were two major differences in bird communities between native and introduced fields: 1) Several grassland birds of conservation concern occurred only in native plantings (Chestnut-collared Longspur, Henslow's Sparrow, Marbled Godwit, Willet, Nelson's Sparrow); and 2) The only grassland bird species that preferred introduced to native plantings were Bobolink and Brown-headed Cowbird. These patterns were consistent among regions and years. Native plantings had lower and less dense vegetation with more litter—features that were preferred by species typical of mixed- and short-grass prairies. Therefore, native plantings may be more valuable in the western portion of the Great Plains. In contrast, introduced plantings should be valuable in the eastern regions as long as fields are allowed to develop litter extensive enough to provide shelter and nesting sites.

Johnson, Wade A.* **A restoration evaluation program for Minnesota**. Minnesota Department of Natural Resources, St. Paul, Minnesota. Email: wade.a.johnson@state.mn.us

A legislative requirement to evaluate habitat restoration projects funded by the State of Minnesota's Clean Water, Land and Legacy Amendment was enacted in 2011. The State Agencies charged with implementing this evaluation program, the Minnesota Board of Water and Soil Resources and Department of Natural Resources, have seated a panel of restoration experts with broad backgrounds to review selected project plans and field assessment reports. The Panel determines if projects apply current science based practices, meet planned goals, what issues exist in implementation and what modifications may improve outcomes. Project evaluations are conducted throughout the State of Minnesota in a variety of habitat types, including wetlands, prairies, forests, rivers, streams and lakeshores. Of nine projects evaluated in 2012 all were considered to be on trajectories that have the potential to meet the project's overall goals. However, deficiencies in planning, documentation and/or implementation were noted for all projects. Common shortcomings were insufficient detail regarding outcome based goals, inadequate planning for vegetation management and the need for long-term protection from land conversion. Four of the nine projects were determined to need follow up site visits to track continued restoration establishment in light of specific threats to project success. The evaluation process has shown that an effective evaluation protocol requires meaningful and equitable assessment techniques and a high degree of collaboration between evaluators and project managers to facilitate improvements in restoration practice. It is anticipated that a minimum of twenty restoration site evaluations will be conducted annually until 2035.

Jorgensen, Niels and Mark Renz*. **Native forb establishment following herbicide applications.** University of Wisconsin, Madison, Wisconsin. Email: njorgensen@wisc.edu

Interest exists in planting mixed forb-grass prairies in the Midwestern United States. Invasive plants are an obstacle that can prevent establishment. Herbicides, while effective and economical at suppressing invasive plants, can injure desirable plants. Often applications are applied prior to planting to minimize injury, but some herbicides can persist in the soil and potentially prevent establishment,

particularly for native forbs. Research conducted in South Dakota and Wisconsin explored tolerance of common forb species planted in mixed prairie systems to treatments of aminopyralid (54 or 123 $g \cdot ae \cdot ha^{-1}$), aminopyralid + metsulfuron (123 $g \cdot ae \cdot ha^{-1}$ + 21 $g \cdot ai \cdot ha^{-1}$), aminopyralid + triclopyr (84 + 840 or 112 + 1120 $g \cdot ae \cdot ha^{-1}$), aminopyralid + clopyralid (54 + 237 $g \cdot ae \cdot ha^{-1}$), clopyralid (237 or 420 $g \cdot ae \cdot ha^{-1}$), or tebuthiuron (448 $g \cdot ai \cdot ha^{-1}$). Herbicides were applied in the July prior to planting native forb species. Following application, native forbs were no till drilled in the fall, as a dormant planting, or the following spring. Plant species density was counted 12, 18 and 24 months post-application. Spring planting increased forb density for 50% of the species, while 25% were increased from the fall planting after 24 months. Herbicide treatment response was also species specific. For one out of 19 planted forbs, herbicide treatments showed reduced establishment compared to untreated areas after 24 months. Twelve planted forbs did not differ in response to any herbicide treatment, while six species increased in density due to at least one of the herbicide treatments. While improvement of plant density was species specific, aminopyralid + clopyralid (54 + 237 $g \cdot ae \cdot ha^{-1}$) improved the most planted forbs after 24 months. There was no interaction between plant timing and herbicide treatments at any time evaluated. Results suggest that many herbicides can safely be used for invasive plant management prior to planting native forbs, and in some cases may improve establishment.

Kelly, Tara L.*. **The reintroduction of bison in a tallgrass prairie**. Belwin Conservancy, Afton, Minnesota. Email: tara.kelly@belwin.org

American bison (*Bison bison*) once roamed the grasslands of North America. Following intense hunting pressure in the 19th century, this keystone prairie species is now currently limited to a few herds in national parks as well as captive commercial operations. Belwin Conservancy is a non-profit organization located in the St. Croix Valley of Minnesota and in 2008 it reintroduced bison onto 150 acres of tallgrass prairie at its preserve. The bison have so far generated considerable interest for the organization and the native ecosystems it protects. Additionally, Belwin Conservancy has observed significant plant community structure and composition changes to the prairie since adding bison. Warm season grasses such as big bluestem (*Andropogon gerardii*) and Indian grass (*Sorghastrum nutans*) previously dominated this tallgrass prairie. Bison were hoped to increase diversity by using a patch burning regime followed by interseeding with native forbs. This three-part management approach (patch burning, interseeding, grazing) began in 2009 and has continued to present. Since 2009, data has been collected on bison grazing preferences and plant community changes. The majority of plots have been grazed, regardless of whether or not the patch had been burned. Warm season grasses were significantly grazed over cool season grasses, which were significantly grazed over forbs across all plots. Percent cover of warm season grasses, cool season grasses and total forbs significantly decreased since 2009. However, decrease in total forb cover is largely due to a decrease in Canadian goldenrod (*Solidago canadensis*); percent cover of native forbs significantly increased during that time.

Knutson, Melinda G.*[1], Cami Dixon[2], Sara Vacek[3], and Patricia Heglund[1]. **Adaptive management on the ground: what we've learned.** [1]U.S. Fish and Wildlife Service, La Crosse, Wisconsin. [2]U.S. Fish and Wildlife Service, Woodworth, North Dakota. [3] U.S. Fish and Wildlife Service, Morris, Minnesota. Email: Melinda_knutson@fws.gov

Those engaged in ecological restoration have a need to monitor outcomes and continually improve their management practices. Adaptive management is the practitioner's tool of choice when there is uncertainty about the best ways to achieve management objectives. Unfortunately, there is a large gap between the theory and the practice of adaptive management. Despite a wealth of published literature about adaptive management, it is difficult to find examples where it has been fully implemented on the

ground by a management agency. The National Wildlife Refuge System and our partner agencies have employed adaptive management in several restoration projects, beginning in 2007. Together we are learning what works and what doesn't with regard to implementation. In our first projects we brought managers together with scientists, modelers, database experts, and adaptive management experts and we used structured decision making to build a shared understanding or framework that unites each project. In short, we've learned how to work together. We've tried various approaches for improving our management as well as creating fertile ground for collaboration and learning. We've learned how to manage the monitoring data and update the models quickly enough to provide management recommendations that inform subsequent decisions. And, we've learned about the challenges (political, social, economic, and practical) of keeping monitoring projects funded and supported at all levels of an organization. In this paper, we will review the core requirements of adaptive management and summarize lessons learned from our first projects.

Krider, Lori*[1], Bruce Wilson[1], Joe Magner[1], Brad Hansen[1], Linse Lahti[2], and Brenda Asmus[3]. **Ecological implications of agricultural drainage ditch restoration through a two-stage design (Mower County, Minnesota).** [1]University of Minnesota, St. Paul, Minnesota. [2]Minnesota Department of Natural Resources, St. Paul, Minnesota. [3]Minnesota Pollution Control Agency, St. Paul, Minnesota. Email: krid0006@umn.edu

Traditional trapezoidal drainage ditch designs are fraught with nutrient and sediment issues that negatively affect the local ecology. Alternative designs have been implemented in various states across the Midwest to help mitigate these problems. Alternative drainage ditches of the two-stage type are designed to mimic natural systems by allowing the low flow channel to meander between floodplain benches. In 2009, the University of Minnesota, The Nature Conservancy and the Mower County SWCD built one of Minnesota's first two-stage ditches, 1 mile in length, 25 minutes southeast of Austin, MN. Multiple years of data have been collected to assess the benefits of this design. Research reveals that although the ditch is areally dominated (>1/2) by non-native and invasive species, namely reed canarygrass (*Phalaris arundinacea*) and great ragweed (*Ambrosia trifida)*, species diversity (52 species in one 30' x 30' plot) and biomass (202 g for a 2-year average of 12, 0.5^2 plots) is high. A large increase in wetland plant species, namely dark green bulrush (*Scirpus atrovirens*) and panicled aster (*Aster lanceolatus)* occurred in 2013 as a result of the unusually wet spring. There was also a 3.8% increase in evapotranspiration (6.3% to 10.1%) during base flow events. The numbers of riffles and pools increased by 1260 and 1525%, respectively, from 5 to 68 riffles and 4 to 65 pools. Lastly, a 9 point increase occurred in the fish index of biological integrity and a 44% decrease in tolerant species occurred from pre-construction to 2 years post-construction. Although much work has been done, further work is needed to fully understand processes during high flow events, to investigate possible modifications to improve the existing design, collecting more data in traditional ditches for comparison purposes and performing a full stream health assessment.

Jacobson, Mark, Jeffrey Lee* and Daniel Tix. **Seed bank and seeding interactions in wetland restoration success.** Barr Engineering, Minneapolis, Minnesota. Email: jefflee@barr.com

Wetland restorations typically rely on seed additions to re-introduce native species and establish wetland plant communities, especially for wetland mitigation. The existing seed bank has often been viewed by regulatory agencies as having limited value for establishing wetland cover on mitigation sites, partly due to historical site disturbances. Three wetland restorations and one wetland creation were completed between 2008 and 2009 in north central Minnesota to mitigate wetland losses. The four sites range in size from 11 acres to 608 acres. Two of the sites (320 and 608 acres) were restored solely using existing seed banks and the other two sites, an 11 acre wetland creation and a 235 acre

restoration were seeded with native wetland species. Each of the sites was monitored annually to document the native species composition and density over the last four years. Following five to six years of development, the sites established using existing seed banks developed similar or greater plant species diversity than those that were seeded. In 2013 the wetlands using existing seed banks had 83 – 131 native hydrophytic species present, while the two seeded sites had 55 - 88 native hydrophytic species present. Landscape position, restoration wetland types, extent and type of wetlands surrounding the sites, and prior land uses were evaluated to determine key variables for success.

Meissen, Justin C.*[1], Susan M. Galatowitsch[1], and Meredith W. Cornett[2]. **Classifying maximum lifespan in perennial tallgrass prairie plants: can we use readily available trait data?** [1]University of Minnesota, Saint Paul, Minnesota. [2]The Nature Conservancy, Duluth, Minnesota. Email: meiss060@umn.edu

In tallgrass prairie restoration, time to establishment is a key factor of success. Maximum lifespan is an important life history trait in perennial plants that can influence the speed of restoration establishment, but it is very difficult to obtain estimates of lifespan with direct measurement. We asked the question: can other, more easily measurable traits such as life form, age of maturity, and clonality serve as indicators of maximum lifespan in perennial tallgrass prairie plants? We surveyed hundreds of published studies to create a perennial plant lifespan classification system of four classes (0-5 yrs, 5-10 yrs, 10-15 yrs, 15+ yrs) based on easy to measure plant trait information. Classification was based on whether species were grasses (Poaceae), species age of maturity (which reflects maximum lifespan), and whether or not species can reproduce clonally. Grasses are longer lived, and clonal vs. non-clonal species with the same age of maturity are longer lived, though they are not as long lived as non-clonal species with greater age of maturity. We tested the efficacy of the classification system using results from the few available long-term measurement studies of lifespan in perennial prairie plants. The classification system correctly predicted the true lifespan class 72% of the time, and only once misclassified to a non-adjacent class (e.g. 5-10 yrs classified as 15+ yrs). These promising results suggest this system may provide a reasonable indication of maximum lifespan in perennial plant species and could be used to inform trait attributes in databases like PLANTS or TRY or better estimate establishment speed in restoration projects.

O'Leary, Mark J.* **Integrating creek, tributary and riparian corridor restoration into park planning and design in Indiana.** SmithGroupJJR. Madison, Wisconsin. Email: Mark.oleary@smithgroupjjr.com

Carmel Creek is a degraded urban waterway that conveys water through Central Park, the premier regional park in the Carmel-Clay Park District (Park District). The creek corridor is urbanized upstream of the park, and wooded along the 970-foot stretch of Carmel Creek that flows through Central Park. Ecological stressors to the creek system included: an undersized and failing culvert at the downstream end of the project area that caused backwater flooding and supersaturated banks; the encroachment of woody invasive species along the riparian corridor that prevented the establishment of soil-stabilizing native plants; debris jambs that caused blowouts in the creek bank; channel widening; and siltation from failing banks and a degraded tributary. Park District goals were to: replace the failing culvert to improve base flows, pass flood flows, and restore habitat connectivity; maintain flood regimes downstream and off site; restore the remnant floodplain forest and mesic woodland; improve in-stream habitat and water quality; and provide residents with opportunities for passive recreation and environmental education. Project investigators completed a baseline analysis of hydrology/hydraulics, ecological communities, and future pedestrian routing. Design solutions included in-stream structures to maintain base flows and re-direct velocities away from the banks;

bioengineering including live stakes, fascines, soil lifts, log drops and boulder placement; riparian corridor restoration through selective woody brush removal, seeding and planting, and wetland restoration. The project was constructed during 2011-2012. This presentation will discuss our approach, process, and lessons learned.

Phillips-Mao, Laura*, Susan M. Galatowitsch, and Jody Refsland. **Developing a qualitative state-transition model to guide implementation of the Minnesota Prairie Conservation Plan.** University of Minnesota, Saint Paul, Minnesota. Email: phil0308@umn.edu

The Minnesota Prairie Conservation Plan sets forth ambitious goals to protect, restore and reconnect native grasslands across western Minnesota. Such landscape-scale restoration planning is challenging due to the site-specific nature of restoration decision-making and implementation. Budgeting for landscape-scale projects requires a method for anticipating restoration prescriptions and costs that is sensitive to site and project variability, but can also be rapidly applied across large landscapes. To address this need, we developed a qualitative state-transition model as a coarse-resolution tool for landscape-scale restoration planning and applied it to two landscapes designated as "core prairie areas" in the Prairie Plan. We identified common "start states" based on vegetation, and "end states" distinguished by plant community and project goals. We assessed which transitions from start to end states could be achieved through restoration, and for a subset, we developed generalized restoration plans incorporating best practices; created seed mixes reflecting commercial availability and regional differences; and surveyed practitioners to estimate the costs of achieving each transition. Cost estimates ranged widely by starting conditions, project goals and restoration targets. Seed mixes and invasion control methods had a large influence on costs, with wet meadow end states and sites requiring selective invasion control or woody species removal being the most challenging and costly to restore. The per-acre cost difference between the cheapest transition—crop to moderate-diversity prairie—and the most expensive—restoring high-diversity wet meadow on a site invaded by reed canary grass (*Phalaris arundinaceae*)—was greater than threefold ($800-$2700). Start states were mapped for each landscape, and transition costs are informing optimization models to maximize conservation benefits per investment dollar associated with implementing the Prairie Plan. Restoration plans, seed mixes and cost estimates will be distributed to conservation implementation teams to guide regional restoration planning and inform private landowners about restoration options.

Reinhardt, Jason R.*[1], Linda M. Nagel[1], and Christopher Swanston[2]. **Searching for focus: indicator species analysis in Michigan oak savannas.** [1]University of Minnesota, St. Paul, Minnesota. [2]U.S. Forest Service, Houghton, Michigan. Email: reinh215@umn.edu

For better or worse, focal species are often used to help set management or restoration goals in conservation projects, especially where resources are limited. The ideal focal species is one that responds to management in a way that reflects the community as a whole (i.e., a true ecological indicator species). In reality, however, many of the species used to set management goals are simply the most charismatic or threatened species within the community. In Michigan oak savanna ecosystems, the leguminous plant wild lupine (*Lupinus perennis*) is often used to set management targets due to its status as an obligate food source for several threatened or endangered Lepidoptera species. Despite the conservation importance of lupine, there may be other plant species that better represent Michigan oak savanna plant communities. Unfortunately, while there is great conservation interest in Michigan oak savanna systems, there are little to no scientific or statistical analyses of potential indicator species. To address this, and identify additional plant species that may be useful in a management context, we conducted a study to identify the most effective ecological and biodiversity indicators in Michigan oak savannas. Plant community survey data were collected from twelve oak

savanna sites on the Manistee National Forest in lower Michigan during the summer of 2013. Surveys were conducted using a variable-scale approach to record the number and density of herbaceous vegetation, shrubs, and trees. A series of in-depth indicator species analyses were used to identify both ecological and biodiversity indicators. Preliminary results suggest that there are a handful of effective indicators for these oak savanna communities, the most effective of which include horse mint (Lamiaceae: *Monarda punctata*) and goat's rue (Fabaceae: *Tephrosia virginiana*).

Rozumalski, Fred J.*. **Human perception of a lakeshore restoration and bioengineered shoreline stabilization ten years after establishment.** Barr Engineering Co. Minneapolis, Minnesota. Email: fjr@barr.com

Ten years ago a twenty foot native plant buffer and bioengineered shoreline was implemented around an eight acre lake in historic Lakewood Cemetery in Minneapolis, MN. The original planting was dominated by forbs and planted entirely with live plugs. Over the past ten years the well maintained shoreline plant community has evolved from a forb dominated community (as planted) to community dominated by sedges. The intention of the restoration in this public space was to create a showy, colorful planting of natives. Originally the owner desired a planting of horticultural perennials, but the project designers persuaded them to implement native species only. What was originally a colorful wildflower display has calmed to a simple grassy appearance. Although the original design intent did not endure, perception of the planting by the public is still positive. This work demonstrates that a well maintained native planting can still be perceived as a beautiful aspect of the landscape even though the color of wildflowers has diminished.

Shuey, John* and Chad Bladow. **Restoring ecological resilience in Indiana oak forest and barrens as adaptation for future climate change regimes.** The Nature Conservancy, Indianapolis, Indiana. Email: jshuey@tnc.org

Future climates are expected to have very significant effects on forest habitats across the Midwest. Prolonged late summer drought-stress, when precipitation is expected to be at its minimum and temperatures at their highest, will likely have the greatest effect on mesic tree species currently dominating the regeneration of dry/mesic systems. Ironically, on-going management of ecological processes (fire suppression) over several decades has increased the mesic nature of southern Indiana forests, further increasing their vulnerability to future climate regimes. If allowed to continue unabated, ecological collapse of mesophied forests is a real possibility in the future. While it sounds intuitively plausible, reintroducing fire alone cannot easily reverse decades of fire suppression and the resulting mesophication. In the proceeding decades, mesic seedlings have matured into pole-sized trees that are reaching the canopy and are less susceptible to fire. The "fire- only" approach can lead managers towards using frequent and intense fires to reverse mesophication, which can have negative impacts on other conservation outcomes as well as the people living around the forests. The alternative approach of manually thinning mesic trees and saplings can restore xeric forest structure, and allow us to use lower intensity prescribed fire less frequently to manage for overstory and herbaceous composition. In Indiana, TNC is using this approach to structurally restore south-central oak woodlands and northwestern oak barrens. In both cases, we are attempting to increase the diversity of species adapted to seasonal and prolonged drought stress such that ecological resilience to predicted future climate regimes is enhanced.

Smiley Jr., Peter C.*[1] and Christian Lenhart[2]. **A review of theoretical frameworks applicable for designing agricultural watershed restoration projects.** [1]USDA Agricultural Research Service, Columbus, Ohio. [2]University of Minnesota, St. Paul, Minnesota. Email: rocky.smiley@ars.usda.gov

Agricultural watershed restoration is the process of assisting the recovery of ecosystem structure and/or function within watersheds that have been degraded and damaged by agriculture. Unfortunately, agricultural watershed restoration is the rare exception within the Midwestern United States despite the need to mitigate environmental damage caused by agriculture. Typical restoration approaches in agricultural watersheds either focus on improving water quality or improving riparian and instream habitat quality. Our objective is to review theoretical frameworks applicable for designing watershed restoration strategies in the Midwestern United States to highlight how these frameworks might be used to design agricultural watershed restoration projects. We identified five theoretical frameworks that include: 1) the Treatment Train Concept; 2) Naturalization; 3) Building Block Model; 4) Rosgen Natural Channel Design; and 5) Riparian Management System. The Treatment Train Concept, Naturalization, and Riparian Management System have been used to design restoration projects in the Midwestern United States. The Building Block Model was developed to design restoration projects in watersheds with extensive agricultural drainage. The Rosgen Natural Channel Design is a widely used design approach in stream restoration. None of the five frameworks explicitly incorporates watershed-scale management. All five concepts promote the restoration of riparian corridors and streams within agricultural watersheds. However, only two concepts (Treatment Train Concept, Rosgen Natural Channel Design) also promote restoration of uplands within agricultural watersheds. Our review suggests that the Treatment Train Concept is the most applicable concept for designing future agricultural watershed restoration projects because it is the most likely to result in holistic restoration projects that involve the use of multiple types of restoration practices implemented within the uplands, riparian corridors, and streams of agricultural watersheds. We recommend holistic approaches towards agricultural watershed restoration because they are the most likely to result in community-based approaches that involve local landowners, agencies, and other stakeholders.

Thada, Adam R., Robert T. Reber, Paul E. Rothrock, and Brad Gordon*. **Interseeding forbs in a grass-dominated prairie restoration in northeast Indiana.** Taylor University, Upland, Indiana. Email: adam_thada@taylor.edu

Many tallgrass prairie restorations fail to match the level of biodiversity found in undisturbed prairie remnants. Restorations often become excessively dominated by warm-season C_4 grasses at the expense of forbs due to the lack of historical disturbance regimes. Interseeding new species usually requires a disturbance mechanism to aid establishment of new plants. We interseeded five native prairie species into a grass dominated restoration in April 2013. Two types of treatments were used in a factorial design: biomass removal by haying or burning, and application of a grass-specific herbicide. After one growing season, seedling counts of sown species and regional natives were higher in plots treated with herbicide. Seedlings of the most abundant sown species, *Parthenium integrifolium,* were taller in plots treated with herbicide. Aboveground biomass of warm-season grasses was greatly reduced by herbicide, reduced even further by a second application, and was found to be negatively correlated with the height of *P. integrifolium* seedlings. Haying increased seedling counts for regional natives, but otherwise was no different than burning. Where management options are limited, grass-specific herbicide application could constitute an effective tool for prairie restorationists interested in increasing floral diversity.

Thomforde, Stephen L.*. **Canvasbacks (*Aythya valisineria*), wild celery (*Vallisneria americana*), and phosphorus regulation in Midwest large shallow water lakes: Novel ideas for restoration.** Great River Greening, St. Paul, Minnesota. Email: stevethomforde@gmail.com

Large shallow water lakes are some of the most productive ecosystems on earth. Tragically, many large shallow water lakes in the Midwest have suffered from eutrophy and have declined in ecosystem function and service. Current restoration attempts focus on decreasing Phosphorus (P) inputs and may be missing the important role of P export mechanisms. Here I utilize ecosystem phenomenology and alternative stable state models to juxtapose functional and dysfunctional ecosystems and highlight the importance of biotic control over nutrient regulation. Changes in biotic controls and corresponding nutrient regulation can cause rapid transitions from the functional to the dysfunctional state. If this assumption is correct, then restoration should also focus on restoring biotic controls which maintain the functional state. To test this assumption, I research Midwest large shallow water lakes that have transitioned from a clear water macrophyte dominated system to a turbid water cyanobacteria dominated system. I use historic documents, loss on ignition analysis, and existing research to identify former biotic controls over P regulation. Results identify numerous historic biotic mechanisms which exported P from the lake, potentially reinforcing the functional clear water state. A strong mechanism existed between the canvasback duck (*Aythya valisineria*) and wild celery (*Vallisneria americana*). Historic migrating canvasback populations feeding on wild celery annually exported 15000 kg of phosphorus out of the lakes. Heavy market hunting of canvasbacks between 1890 and 1910 eliminated the canvasback-wild celery P export mechanism causing the clear water state to transition into the turbid water state. In conclusion, lake managers seeking to restore the clear water state should also focus on restoring biotic controls which actively mine and export in-lake P. These management techniques include in-lake biomass harvests and shoreline restorations which facilitate P export.

Umek, Lauren* and Louise Egerton-Warburton. **Restoration and management effects on litter decomposition and microbial functioning in the Chicago Wilderness.** Northwestern University, Evanston, Illinois and Chicago Botanic Garden, Glencoe, Illinois. Email: lumek@u.northwestern.edu

Ecological restoration seeks to restore the entire ecosystem, including not only native organisms, but also ecological processes, to support long-term sustainability. The decomposition of leaf litter is recognized as an important component of ecological process in terrestrial ecosystems, and provides the most important source of nutrients and organic matter to plant roots and soil organisms. However, the impact of restoration and land management on these process is poorly documented. We investigated the impacts of aboveground restoration practices on leaf litter decomposition and functional microbial diversity. Mesh litterbags containing *Andropogon gerardii*, *Rudbeckia subtomentosa* or *Baptisia australis*, (representing a grass, forb and legume species, respectively) were installed in 24 study sites that comprise a subset of the Chicago Wilderness Land Management Research Program (100 Sites for 100 Years). These sites include remnant prairies and former row-crop prairie restorations that are replicated along a restoration chronosequence. Across these sites, increasing time under management is associated with decreasing soil fertility and plant community composition that is more similar to high quality reference prairies. We measured decomposition as mass loss in the field, and evaluated functional microbial diversity as the activity of extracellular enzymes that catalyze the degradation of leaf litter. The largest differences in decomposition occurred between litter types rather than between sites of differing management histories, and there was no direct relationship between mass loss and enzyme activity. However, enzyme activity was highly variable among litter types and sites. Such variations in enzyme activity among litter types suggest that the strong differences in litter chemical and physical properties may have overwhelmed any direct relationship between enzyme activity and mass loss. These results suggest that land use history and management practices may influence plant community development, and but have less influence on decomposition through mass loss or enzyme

activity.

Volke, Malia* and W. Carter Johnson. **The emergence of reservoir deltas in the regulated Missouri River: Opportunities for cottonwood forest restoration.** South Dakota State University, Brookings, South Dakota. Email: malia.volke@sdstate.edu

Recent studies of riparian forests along the regulated Missouri River forecast a bleak future for the once expansive cottonwood forest ecosystem. The majority of the vast cottonwood forests of the type described by Lewis and Clark in their journals were permanently destroyed under large reservoirs when the big dams were built a half century ago. Remnant cottonwood forests, which are mostly confined to gaps between reservoirs, have failed to regenerate in the flood-protected post-dam environment and are now approaching the end of their lifespan. As remnant forests have senesced, large deltas have begun to form at mainstem and tributary confluences with reservoirs. Although largely unstudied, available evidence suggests that these delta habitats may support native riparian vegetation that is of the type in decline throughout the Missouri River system. The delta formed at the confluence of the White River and Lake Francis Case on the Missouri River in South Dakota represents a novel habitat where riparian forest has expanded during the post-dam era; however, expansion may be curtailed at times by high stages of Lake Francis Case that cause forest mortality. Analysis of aerial photography showed that riparian forest area in the delta increased by 69 percent in the post-dam era. Field inventories determined that a heterogeneous mixture of riparian forests exists within the White River delta, and that these forests are similar to those along natural river reaches. The expansion of cottonwood forests on novel delta habitats has occurred in the absence of any active restoration efforts or reservoir management. Current research will lead to an improved understanding of how a targeted restoration approach could improve rates of cottonwood expansion and survival in novel delta habitats along the Missouri River.

POSTER PRESENTATION ABSTRACTS (ALPHABETIC)

Anderson, Roger C.*[1], Jamie Herold[1,2] M. Rebecca Anderson[1], Jonathan T. Bauer[3], and Victoria Borowicz[1]. **Comparison of the effect of early and late removal of second-year garlic mustard (*Alliaria petiolata*) on first-year plants and deciduous forest spring and summer dominant herbaceous groundlayer species in central Illinois, USA.** [1]Illinois State University, Normal, Illinois. [2]Purdue University, West Lafayette, Indiana. [3]Indiana University, Bloomington, Indiana. Email: rcander@ilstu.edu

Garlic mustard, a biennial Eurasian species, has extensively invaded eastern North American deciduous forests. We studied effects of three years (2005-2007) of annual removal of second-year garlic mustard plants on first-year plants and native spring herbaceous species in upland and lowland woods. Treatments compared removal of second-year plants in mid-March (Early Treatment) or mid-May (Late Treatment) to a control. First- and second-year plants and native herbaceous species percent cover were recorded on April 19 and 20. First-year garlic mustard plant cover was higher on Control than Treatment plots; however, in the Upland Woods only Control and Late Treatment differed significantly. First-year plant cover was less in removal than Control plots, indicating reduced seed input; however, we found no difference in cover of second-year plants between Late Treatment and Control plots. Results suggest second-year plants strongly compete with younger conspecifics and their removal decreases first-year plant mortality. Removal of second-year garlic mustard did not significantly affect total cover of native herbaceous species. Second-year plants complete vegetative growth before late May, and might impact early developing native species more than later growing species. We tested effect of removal of second-year garlic mustard on native species in two phenological categories: spring and summer dominant species. We found no Treatment effects on summer dominant species. However, Early Treatment plots had significantly more cover of spring dominant plants than Late Treatment and Control in the Upland Woods. Species Indicator Analysis indicated a majority of spring (75%) and summer (50%) dominant species maximized performance in the Early Treatment.

Anderson, Roger C.*[1], Peter C. Smiley Jr[2], Jen Lyndall[3], and Young Choi[4]. **Midwest-Great Lakes SER Chapter: Who we are, what we do, and what we will do.** [1]Illinois State University, Normal, Illinois, [2]USDA-ARS, Soil Drainage Research Unit, Columbus, Ohio, [3]ENVIRON, Burton, Ohio, [4]Purdue University Calumet, Hammond, Indiana. Email: rcander@ilstu.edu

Midwestern United States consists of 12 states and six of them (Minnesota, Wisconsin, Illinois, Indiana, Michigan, and Ohio) contact Great Lakes. This subregion defines the boundaries of the Midwest-Great Lakes (MWGL) Chapter of the Society for Ecological Restoration (SER). This region has a diversity of ecosystems including prairies, a variety of forest types, savannas, wetlands, aquatic habitats including the Great Lakes, and wilderness areas. This diverse geographic area is impacted by agriculture, industry, urbanization, and invasive species. Consequently, ecological restoration projects within this region face a wide range of challenges. The MWGL SER Chapter was established in 2008 with a mission of promoting the science and practice of ecological restoration to assist with recovery and management of aquatic and terrestrial ecosystems within this region. Promotion of ecological restoration is critical for facilitating coordination and supporting grassroots restoration efforts. To communicate with chapter members and others we established a chapter webpage, developed a Facebook page, regularly publish chapter newsletters, and hold annual chapter meetings. Our first five annual meetings (2009-2013) include sessions for oral and poster presentations, workshops, symposia, and at least one plenary session. In 2012, we filed our articles of incorporation and were formally recognized as a domestic non-profit organization by the State of Indiana and. Last year, (2013) we

were recognized as nonprofit public foundation [501(c)(3)] by the United States Internal Revenue Service, and completed a 5-year strategic plan that incorporated input from our membership and will guide the selection of our future activities.

Aten, Nancy M.* and Daniel J. Collins. **The development of an ecological restoration approach and suite of site-specific projects beneficial to the conservation of a Door County, Wisconsin landscape using concepts from Christopher Alexander's "A Pattern Language".** Landscapes of Place LLC, Mequon, Wisconsin. Email: nancyaten@landscapesofplace.com

A pattern language, a term coined by architect Christopher Alexander and popularized by his book A Pattern Language, is a structured method of describing good design practices within a field of expertise. Borrowing from these concepts, a Wisconsin Coastal Management Program-funded project team is producing a 30-year land restoration and conservation vision consisting of step-wise, overlapping, grantable projects to be implemented as resources/capabilities allow. The Pattern Language approach is intended to simplify complex design work. It allows planners to start the process from any part of the problem presently understood, and work toward the unknown parts. Patterning permits integration of elements that cross subject and time domains. Each pattern by construction defines a beneficial outcome. A range of restoration projects, each developed from a pattern, can then be prioritized and knit with the plan as a whole. Domains could include land management projects (exotic invasive work, reforestation work, etc.), habitat protection, community engagement, policy, trail extensions, wetland services (flood abatement, surface water supply, water quality protection, shoreline protection, culvert improvements), and researchers or research facility support as examples. This process is being applied to a 1700-ha state natural area presently owned by multiple private landowners and land trusts. The poster will present intermediate findings of the multidisciplinary team and process.

Damm, Mary C.*[1], Marc Bogonovich[2], and James D. Bever[1]. **Micro-scale plant community composition differs between native and reconstructed Iowa tallgrass prairies.** [1]Indiana University, Bloomington, Indiana. [2]Openwords LLC, Bloomington, Indiana. Email: marydamm@gmail.com

The tallgrass prairie is a highly diverse and endangered ecosystem. Small-scale plant richness is high (26 species in 0.5 m^2 plots) in native black-soil prairies. Prairies have been planted throughout the Midwest in an attempt to recreate the lost landscape, but even older reconstructions do not have the richness of native prairies. Small-scale richness is not replicated. In this study, we asked whether the difference in richness between native and reconstructed prairies observed at the small-scale (plot) is also observed at micro-scales (overlapping plant canopies). We collected data in 3 native and 2 reconstructed Iowa prairies in 0.5 m^2 plots using the point-intercept method, recording species at 49 grid points within the plot. We employed several metrics to analyze micro-scale plant community composition in the prairies. We also developed a new metric, point richness, the number of species at a grid point. Native prairies have greater plot richness ($\mu = 19.0$, SE = 0.84, $p = 0.014$) and point richness ($\mu = 2.7$, SE = 0.13, $p = 0.004$). Plot richness is correlated with average point richness in native prairies ($r = 0.735$, df = 20, $p < 0.0001$), but not in reconstructed. Plant composition differences between points measured by Euclidean distance generally increased with physical distance within plots ($F_{1,33} = 104$, $p < 0.0001$), while differences measured with Jaccard's similarity generally decreased ($F_{1,33} = 194$, $p < 0.0001$), but both relationships differed between prairie types. Euclidean distance was greater in native prairies, indicating species composition of neighboring plants is more dissimilar. Jaccard's similarity was higher in reconstructed prairies between 0-50 cm, indicating neighbor species were more similar in reconstructions over this physical distance. The patterns found in our study

suggest mechanisms operating at a very small scale. Diverse microbial communities and heterogeneous soil nutrients are two possible mechanisms.

DeJoode, Daniel R.*[1], Glenn Vande Water[2], and Fred J. Rozumalski.[1] **Large-scale transplantation results of dwarf lake iris (*Iris lacustris*) and Houghton's goldenrod (*Solidago houghtonii*) after three growing seasons.** [1]Barr Engineering Company, Minneapolis, Minnesota. [2]Vande Water Natural Resource Services, Escanaba, Michigan. Email: ddejoode@barr.com

Two state and federally threatened plant species, dwarf lake iris (*Iris lacustris*) and Houghton's goldenrod (*Solidago houghtonii*), were relocated prior to a pipeline project in Mackinac County, Michigan. Plants were transplanted to unoccupied locations within 250 m of their original locations in June 2011. Clonal populations of dwarf lake iris, totaling over 100,000 plants (ramets) across 500 m^2, were relocated using sod transplant techniques. Over 1,200 individuals of Houghton's goldenrod were relocated as individually dug plants. An unquantified number of Houghton's goldenrod plants were also relocated in the sod with dwarf lake iris. Supplemental watering was provided for one growing season following relocation. The relocated dwarf lake iris population increased slightly in spring 2012, and then decreased slightly. In the third growing season (2013), plants were vigorous and undergoing sexual and asexual reproduction, and the population size was 91 percent the size of the original transplanted population. Survival of individually-relocated Houghton's goldenrod plants was 58 percent after three growing seasons. The proportion of the goldenrod population that bloomed declined from approximately 37 percent in 2011 to one percent in 2013. Anecdotal observations of sod-relocated Houghton's goldenrod indicate similar vigor and flowering success as nearby naturally-occurring plants, whereas individually relocated Houghton's goldenrod showed decreased vigor and reproduction. Transplantation of native plant species, and particularly threatened and endangered species, can be challenging. This work demonstrates the utility of sod-relocation methods for large-scale transplant of shallowly-rooted threatened and endangered plant species.

Eachus, Brian*, Dan Gibson, Karen Davison, Devin Gilbertson, and Molly B. McNicoll. **Effects of management on *Pastinaca sativa* (wild parsnip) in a low-diversity grassland.** Luther College, Decorah, Iowa. Email: eachbr01@luther.edu

Management of noxious, monocarpic perennial species may attempt to eliminate reproductive adults to reduce the number of current and future individuals. *Pastinaca sativa* (wild parsnip) is a non-native biennial forb managed because of its impacts on human and other animal skin through phytophotodermatitis. We used three different treatments to control *P. sativa* adults prior to setting seed, each affecting a different part of the plant: scything severed flowering stems above-ground, root-cutting severed plants several centimeters below-ground, herbicide systemically killed the entire target plant, and control plots were unmanipulated. All treatments were replicated (x 7), and also tested for the effect of prescribed fire in a burn and no-burn design, with burn plots exposed to annual, late spring controlled burns. After two years of targeted control measures and three consecutive years of prescribed fire, number of reproductive *P. sativa* was one half to one third less abundant in burn plots than no-burn plots. In burn and no-burn plots, number of *P. sativa* adults was greatest in the scythe treatment, and generally similar among control, herbicide, and root-cut treatments. Species richness and vegetation density were generally similar among treatments, although vegetation density was greater in the no-burn than burn plots. Density of dominant cool-season grasses was generally similar among *P. sativa* treatments, and greater in no-burn than burn plots. This pilot study indicates that multiple, annual, late spring burns may provide significant reduction of *P. sativa*, possibly resulting from mortality of adults, rosettes, and/or seed bank. In contrast, the greater number of of *P. sativa* in scythe treatments, an effect similar to mowing *P. sativa* and neighboring vegetation, may create

favorable growth conditions for *P. sativa*. These results suggest that management methods can greatly differ in their effectiveness, ranging from population reduction to population growth of *P. sativa*.

Gibson, Dan*, Brian Eachus, Karen Davison, Devin Gilbertson, and Molly B. McNicoll. **Understory community structure response to mechanical thinning and fire regime in an oak woodland restoration in Northeast Iowa.** Luther College, Decorah, Iowa. Email: gibsda01@luther.edu

Response of understory community structure to oak woodland restoration may vary based on canopy openness and frequency of fire. Reduction of canopy cover via mechanical removal of trees increases light availability, but fire regime may alter diversity of the understory based on fire tolerance. In this pilot study, the canopy was thinned *Juniperus virginiana* and *Juglans nigra* to leave mature oak trees (*Quercus macrocarpa*), which increased canopy openness by more than 50 %. After thinning, plots (~⅓ acre) were assigned one of three treatments (burn yearly, burn every other year, and no-burn) and two control plots were not thinned or burned. All burns were implemented in the spring, after snow melt. After five years of treatments, species richness of the understory was greatest in the thinned, no-burn plot and lowest in the thinned, yearly burned and control plots. Among burn regimes, the difference in species richness was primarily due to the presence of woody saplings, vines, and shrubs (including *Parthenocissus quinquefolia*, *Rubus* spp., and *Rhamnus cathartica*) in the no-burn and alternate-year burn plots compared to the yearly burn plots. Abundance of herbaceous species was greatest in the thinned, yearly burned plot (~20 % greater than thinned, no-burn plot, 40 % greater than control plots). Herbaceous species present were common to degraded woodlands in the region and likely reflect the history of the woodland and the young age of the restoration. In this woodland restoration, mechanical thinning increased woody species richness in the understory, likely from increased light availability. Annual burns combined with thinning, offset the number of woody species in the understory, likely eliminating them by fire intolerance. Overall, these results indicate that thinning in combination with burning is more likely to maintain an open understory dominated by herbaceous vegetation, structure that is characteristic of open oak woodlands.

Gordon, Brad*[1], Paul Rothrock[2], and Paul Labus[3]. **Oak savanna and wetland benchmarks developed for calculating site vegetation quality categories.** [1]University of Minnesota, St. Paul, Minnesota. [2]Taylor University, Upland, Indiana. [3] The Nature Conservancy, Merrillville, Indiana. Email: bradgordon18@gmail.com

The Tolleston Strandplain at the southern end of Lake Michigan offers a unique "dune and swale" topography supporting oak savannas on the dunes and a mosaic of wetland communities in the swales. Following years of human degradation, the sites in this area are now being restored. In this effort, assessments of vegetative quality in these sites have been necessary for proper management decisions. However, it is poorly understood what indices best reflect the vegetative quality of these oak savannas and wetlands. In this study, biological benchmarks were developed which employ expert best professional judgment (BPJ) for determining the best indices for these community types. Experts used a variety of metrics to place each of 63 transects from this unique landscape into one of four quality categories: 1) "good to very good," 2) "medium," 3) "poor," and 4) "very poor." Using discriminant analysis, the weights of importance for each expert's metrics were determined alongside the range of values for these metrics. These weights and ranges were used to develop a point system of benchmarks which place transects into one of the four quality categories based on the transect's quantitative data. The benchmarks can then be used as a decision making tool to determine what future actions are necessary to achieve the goal of restoring the biodiversity and a historical representation of vegetation in the oak savannas and wetlands of this unique landscape.

Kinsman, Samantha J.*, Rachel Shmagranoff, and Young D. Choi. **The birds of Wolf Lake.** Purdue University Calumet, Hammond, Indiana. Email: samanthakinsman@gmail.com

Wolf Lake in Northwest Indiana recently underwent restoration to repair the human disturbance it has undergone during the 19th and 20th century. The disturbance was in the nature of partitioning by causeways, railroads and dikes, being filled with slag from the nearby steel industry, and sand extraction. Much of the wetland vegetation had suffered from the reduction of native species and the invasion of exotic species. The restoration effort during 2004-2007 reconstructed 1.5 km of the Wolf Lake shore line, rebuilt 10 hectares of islands that were historically present in the lake, and removed exotic plant species and replace them with native ones. In 2013, we conducted a survey to investigate how the restored habitat was used by native bird species. Biweekly observations occurred during the spring and fall migration seasons to document the number and species of birds that used Wolf Lake as a migratory stop over, and the 10 islands and shore line were surveyed for nesting sites during the summer months of June and July. Of the 65 bird species that were observed, Canada Goose (*Branta canadensis*), Great Blue Heron (*Ardea herodias*), Killdeer (*Charadrius vociferous*), American Kestrel (*Falco sparverius*), and Dark-eyed Junco (*Junco hyemalis*) were the most common of the categories of waterfowl, wading birds, shorebirds, raptors, and perching birds, respectively. In addition, a total of 74 nest sites were recorded for Canada Geese (*Branta Canadensis*), Spotted Sandpipers (*Actitis macularia*), Red-winged Blackbirds (*Agelaius phoeniceus*), Mallards (*Anas platyrhunchos*), Killdeer (*Charadrius vociferous*), Yellow Warbler (*Dendroica petechia*), and Marsh Wren (*Cistothorus palustris*).

Larson, Diane L.*[1], Doug Wells[2], Sara Vacek[3], Paul A. Rabie[4], Nick Palaia[5], Jennifer L. Larson[6], Pauline Drobney[7], and JB Bright[3]. **Can we use theories of complementarity and limiting similarity to reduce exotic infestation in prairie reconstructions?** [1]U.S. Geological Survey, St. Paul, Minnesota. [2]U.S. Fish and Wildlife Service (FWS), Fergus Falls, Minnesota. [3]U.S. FWS, Morris, Minnesota. [4]WEST, Inc., Cheyenne, Wyoming. [5]U.S. FWS, Litchfield, Minnesota. [6]Polistes Foundation, St. Paul, Minnesota. [7]U.S. FWS, Prairie City, Iowa. Email: dlarson@usgs.gov

Principles of resource availability often guide our restoration strategies. For example, greater plant species richness should utilize a larger proportion of resources (complementarity) and thus leave little available for invaders. Likewise, functional groups similar to an invader should most effectively exclude that invader by preferentially using resources it needs. Prairie reconstruction, however, begins from the (relatively) blank slate of a previously farmed field, devoid of vegetation. Can theory that relies on biotic interaction be used to reduce exotic plant invasion into new reconstructions? We examined this question in nine tallgrass prairie reconstructions in Minnesota and Iowa. Seed mixes that varied in species richness (10, 20, or 34 species) were planted in 12 m x 12 m treatment cells and replicated 12 times in each field. Planting occurred in 2005 and the last survey of species richness and cover was completed in 2010. Although planted species richness did increase with seed mix richness, analysis of variance among the three categories found no difference in infestation by exotic species as a group or by Canada thistle. However, we did find a negative correlation between planted species richness and exotic cover, and surprisingly, also between native non-planted species richness and exotic cover, suggesting that early-successional "weedy" native species contributed to exotic resistance in these young reconstructions. In addition, although we expected that both planted and native non-planted Asteraceae would have the most negative effect on Canada thistle, we found that early, robust establishment of any species, but especially the cool-season grasses, had negative effects on cover of Canada thistle. We conclude that (1) even in new prairie reconstructions, increasing the seed mix richness can reduce infestation by exotic plants, and (2) we should not underestimate the value of early successional species that emerge from the existing seedbank for resisting exotic plant invasion.

Loebach, Chris A.* and Roger C. Anderson. **Investigating epizoochory as a seed dispersal mechanism of the invasive plant garlic mustard (*Alliaria petiolata*).** Illinois State University, Normal, Illinois. Email: cloebac@ilstu.edu

Garlic mustard is an herbaceous Eurasian plant that has aggressively invaded deciduous forests of eastern North America and is a major threat to forest groundlayer species. The ecology of garlic mustard has been well studied with the exception of seed dispersal mechanisms. External mammal transport (epizoochory) is often cited as a dispersal mechanism, but this hypothesis has never been tested. We tested for epizoochory using a randomized block design containing a mammal inclusion treatment (MIT) and a control. Both treatments included a germination tray filled with potting soil placed into the ground with the top edge of the tray flush with the soil surface. To exclude mammals, a wood-framed exclosure (10.6 cm H x 61 cm L x 30.5 cm W) covered with wire mesh was placed over control trays. For the MIT, a wooden frame (30.5cm H x 61cm L x30.5 cm W) was covered with poultry fencing, except the two smaller (30.5 cm x 30.5cm) ends were left uncovered so mammals raccoon size or smaller could move through the MIT. A metal pie pan attached to a wooden cross piece in the frame center was filled daily with shelled corn and sunflower seeds. Motion sensitive cameras recorded animals entering the treatment. After the majority of seeds were dispersed, trays were collected and brought to ISU to receive cold-moist stratification during winter, which is necessary for seed germination. In spring 2014, garlic mustard seedlings in each tray will be counted. If epizoochory is a dispersal mechanism, then there should be significantly more seedlings in MIT than control trays. We counted non-garlic mustard seedlings this past fall (2013). MIT trays contained an average of 6.6 (±2.86) seedlings compared to 2.4 (±0.82) in controls. While this difference was marginally significant ($F_{1,11.84}$=4.21, p=0.0629), it suggests mammals transported seeds into the MIT. If the same trend occurs for garlic mustard seedlings, then the hypothesis that epizoochory is a dispersal mechanism will be supported.

Ohrtman, Michelle K.*, Sharon A. Clay, and Alexander Smart. **Box elder (*Acer negundo*) as a bottom-up control for saltcedar (*Tamarix* spp.) in the northern Great Plains.** South Dakota State University, Brookings, South Dakota. Email: michelle.ohrtman@sdstate.edu

Saltcedar (*Tamarix* spp.) is a noxious weed associated with billions of dollars in economic and ecological losses in the western United States. Herbicide applications are the primary mechanism for killing mature plants but producers and land managers may prefer to use more natural control methods in the northern Great Plains to avoid unnecessary damage to coexisting plants and enhance wildlife habitat. Box elder (*Acer negundo*) is a shade-tolerant native tree that has been observed to establish underneath saltcedar canopies, outgrow and eventually kill these exotic plants in northwestern Colorado. Competitive interactions between these plants have not been observed in the northern Great Plains. We examined the potential for establishment of box elder under saltcedar canopies to serve as a future bottom-up control for mature saltcedar in the field. Trees were planted on Forest Service land along the Cheyenne River in Pennington County, SD in May 2013. Bare root cuttings were planted both under the canopy of mature saltcedar plants and in adjacent open areas at 4 locations across the site. Trees were assigned a combination of treatments (with or without monthly watering, mulch, and 6-foot tree protectors). Tree survival and height were recorded at the end of the growing season. Box elder plants established equally well (> 90% survival) under mature saltcedar canopies (80 to 95% shade based on monthly PAR measurements) and in open areas but survival and growth varied by planting location and protector treatment. In open areas, trees with protectors showed greater survival and growth. Growth and survival of trees was greater under saltcedar canopies in the northeast planting location but the opposite was observed in the south planting area. Results suggest that establishment of bottom-up controls to provide competition for mature saltcedar plants may be viable options for saltcedar management in the northern Great Plains.

Peterson, Donnie*, Steve Yaninek, and Cliff Sadof. **Suitability of green ash (*Fraxinus pennsylvanica*) and blue ash (*F. quadrangulata*) to emerald ash borer (*Agrilus planipennis*) and their potential to serve as a refuge for biological control agents.** Purdue University, West Lafayette, Indiana. Email: peter207@purdue.edu

Blue ash (*F. quadrangulata*) is the species of ash tree that is least susceptible and most likely to be survive able to emerald ash borer (EAB) attack. If natural enemies, such as parasitoids, are able to parasitize the EAB beneath the bark of blue ash, then parasitoids might be able to persist to protect regenerating ash trees. Suitability of blue and green ash trees to EAB were determined by infesting them with EAB. The parasitoid, *Tetrastichus planipennisi* was then introduced when majority of EAB larvae were 3rd instar or larger. EAB eggs used to infest the trees were 86.7% viable. Overall, 83.7% and 62.9% of viable larvae in blue and green ash, respectively, survived to the end of the first fall. Additionally, 64.4% and 85.5% of EAB larvae in blue and green ash, respectively, were able to overwinter as prepupae. EAB larvae infesting blue ash were smaller, 2.77 mm prothoracic width, compared to EAB larvae infesting green ash, 3.08 mm prothoracic width. *Tetrastichus planipennisi* successfully parasitized EAB larvae on 36% of infested green ash trees. This rate of attack may have been low because average bark thickness, 3.08 mm, was close to the maximum thickness that this parasitoid can penetrate with its ovipositor. Although only 11.2% of the larvae were parasitized, parasitism rates on individual trees reached as high as 66.7%. Blue and green ash trees are both able to support EAB. EAB infesting blue ash were slightly slower to develop, but they had higher survival rates. This provides support that blue ash could be a refuge for parasitoids. Further work is being conducted to determine if *T. planipennisi* can parasitize EAB infested blue ash. Infested green ash were able to support *T. planipennisi*.

Ross, Nikol*, Christian Lenhart, and Dean Current. **Effectiveness of nitrate reduction in a constructed wetland receiving tile-drainage water from an agricultural field in along Elm Creek, a Blue Earth River tributary in south central, Minnesota.** University of Minnesota, St. Paul, Minnesota. Email: bier0137@umn.edu

Excessive nitrate is a major cause of water quality impairments in the upper Midwest. Extensive tile drainage systems in agricultural fields allow nitrates to be discharged directly into public surface waters. This nitrate rich water travels to the northern Gulf of Mexico where it contributes to the hypoxia problem. This project addresses the problem by redirecting agricultural tile drainage water through a three celled constructed wetland before the water is discharged into the adjacent Elm Creek. The wetland captures sub-surface drainage from a 30-acre agricultural field in south central Minnesota within the Blue Earth River watershed. Typically, in this region subsurface tile drainage is greatest in the spring months and lower flows occur during the growing season because of higher evapotranspiration rates. Nitrate removal occurs when denitrifying bacteria in soils convert dissolved nitrates in water to di-nitrogen gas (N_2) which is released into the atmosphere. Ideally the local hydrologic soils and native wet-prairie mix seedlings in the wetland would help with this process. Throughout the 2013 field season nutrient and hydrologic data were taken at the inlet, outlet and in the throughway between ponding cells. Nitrate concentrations were expected to reduce as water traveled though the wetland, but the data on these concentrations did not show a significant reduction. However, the overall volume of water from the tile drainage inlet was reduced by 82% before it was discharged into the creek. Thus, the overall load of nitrate discharged into the surface waters was reduced by 298.0 lbs. The results of the project show that even in the first year of establishment, this constructed wetland was effective at reducing surface water nitrates. As organic carbon builds up in this wetland results should only improve. Lessons learned from this treatment wetland will be useful in similar projects around the region.

Smiley Jr., Peter C.*[1], Kathryn R. Rumora[2], and Krystal R. Seger[3]. **Implications of the results of colonization experiments for designing riparian restoration projects adjacent to agricultural headwater streams.** [1]USDA Agricultural Research Service, Columbus, Ohio. [2] Ohio State University, Columbus, Ohio. [3]Tulane University, New Orleans, Louisiana. Email: rocky.smiley@ars.usda.gov

Many headwater streams and their riparian habitats in the Midwestern United States have been modified for agricultural drainage. Agricultural drainage often results in reductions of physical habitat diversity, shifts from woody to herbaceous riparian vegetation, and the loss of riparian habitat. The effects of these riparian habitat modifications have been widely documented for instream macroinvertebrates, but less is known about how changes to riparian vegetation influences aquatic macroinvertebrates within the riparian zones of agricultural headwater streams. Our objective is to highlight how the results of colonization experiments can provide science-based information that can be applied towards restoring riparian zones of agricultural headwater streams. Colonization experiments involve the placement of water-filled mesocosms lacking nutrients, organic matter, and aquatic macroinvertebrates into the environment and documenting changes in habitat and aquatic macroinvertebrates throughout the experiment. We conducted two colonization experiments adjacent to agricultural headwater streams in central Ohio in the summer of 2009 and 2013 to determine if aquatic macroinvertebrate colonization differed among riparian zone types (i.e., unplanted herbaceous riparian zones, planted herbaceous riparian zones, forested riparian zones) present within seven agricultural headwater streams. Physical habitat, water chemistry, and/or aquatic macroinvertebrates were sampled from July to August 2009 and June to August 2013. Our 2009 experiment found that aquatic macroinvertebrate diversity and zooplankton relative abundance was greater in forested riparian zones having greater canopy cover than herbaceous riparian zones. Preliminary results from our 2013 experiment indicated that mesocosms within forested riparian zones with greater canopy cover exhibited lesser mean water temperatures than those within herbaceous riparian zones with reduced canopy cover. Results from our colonization experiments suggest that restoration projects that lead to increases in riparian width and increases in the amount of riparian woody vegetation adjacent to agricultural headwater streams will benefit aquatic macroinvertebrates living within these riparian zones.

Triplett, Laura J.*. **Riparian vegetation establishment and variation in hydrologic timing within the Lower Minnesota River Basin.** University of Minnesota, St. Paul, Minnesota. Email: Tripl023@umn.edu

This study investigates the relationships between hydrologic timing and riparian vegetation establishment; specifically the impact of changes in hydrology on the colonization of riparian vegetation. How do changes in hydrology, such as the timing and duration of base and peak flow events; affect the recruitment, germination, and establishment of vegetation on pointbars? Recent low and median flow increases have been observed within the study area of the Lower Minnesota River. These flow increases have been associated with reductions in woody riparian vegetation establishment through decreased pointbar exposure time during low and median flows and through scouring processes at high flows. Reduction in woody riparian vegetation establishment can lead to reduced pointbar growth and sediment deposition; further promoting river widening and increased sediment loading. It is hypothesized that a shift toward young woody seedlings over established saplings will be observed. Observance of earlier seeding species such as silver maple and cottonwood is also expected, along with high frequencies of annual herbaceous and graminoid species such as smartweed and lovegrass. High frequencies of species with rapid growth habits or alternative forms of propagation such as sandbar willow are also expected. These patterns have been observed in preliminary analysis of 2013 vegetation survey data. Historical patterns in vegetation establishment are also being documented

through analysis of historical aerial photography and associated historical stream flow data available within the study area. Preliminary historical analysis has revealed patterns of pointbar vegetation growth during decades of low flow as well as inhibited vegetation growth during decades of higher flow.