2018 Forestry and Wildlife Research Review

Thursday January 11, 2018
Cloquet Forestry Center
Cloquet, MN
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<td>Meredith Cornett, <em>TNC</em></td>
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<td>Assessing Quaking Aspen Stress and Mortality Along a Climate Gradient in Northern Minnesota</td>
<td>Ryan Ness, <em>BSU</em></td>
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<td>Laura Reuling, <em>WI DNR</em></td>
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<td>Alan Toczydlowski, <em>UMN-FR</em></td>
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<td>Examining the effects of timber management on water quantity and water quality in the Upper Midwest</td>
<td>Lucy Rose, <em>UMN-FR</em></td>
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<td>Peter Jacobson, <em>DNR-Fisheries</em></td>
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<td>Ten Years Post-Harvest: Results from the Wisconsin Northern Hardwoods Managed Silviculture Study</td>
<td>Dustin Bronson, WI DNR,  Kyle Gill, UMN-CFC, Stephanie Snyder, USFS,  Jacob Muller, UMN-FR,  Charlie Blinn, UMN-FR, Nicholas Walton, UMD-NRRI</td>
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<td>Recent and ongoing silviculture research at the Cloquet Forestry Center</td>
<td>Kyle Gill, UMN-CFC</td>
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<td>Lake States Maple Syrup Producers and Their Attitudes Towards and Responses to Economic, Social, Ecological, and Climate Challenges</td>
<td>Stephanie Snyder, USFS</td>
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<td>Seedling Response to Adaptive Silviculture Treatments Aimed at Climate Change in Northern Minnesota</td>
<td>Jacob Muller, UMN-FR</td>
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<td>Minnesota Breeding Bird Atlas</td>
<td>Nicholas Walton, UMD-NRRI</td>
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<td>Does Wildland Fire Cause Increases in Mercury in Fish?</td>
<td>Trent Wickman, USFS-Eastern Region, Duluth</td>
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<td>A foundational data set characterizing historic forest attributes and disturbance patterns</td>
<td>Jody Vogeler, UMN-FR</td>
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<td>Urban Tree Canopy Mapping and Measuring using High-Resolution Remotely Sensed Data</td>
<td>Trevor Host, UMN-FR</td>
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Denotes a Lightning Talk

**Poster-only presentations not listed above:**
Methylmercury Accumulation in Wildlife in an Upland Forest-Peatland Habitat. Susan Eggert, USDA-NRS

Mapping of Black Ash Forest Threatened By Emerald Ash Borer In Northern Minnesota, USA. Peder Engelstad, CSU

Individual detection and plot-wide estimation of coarse woody debris density and volume using airborne LiDAR, Michael Joyce, UMD-NRRI
Welcome and Overview

Welcome to SFEC’s 2018 Forestry and Wildlife Research Review!

The Research Review is one of our most important events. Each year it brings together a large and diverse group of natural resource professionals for updates on research relevant to their work. The presentations, questions, and discussion from wildlife managers, foresters, ecologists, water resource specialists, outreach professionals, students, and others bring us all up to speed on new developments and how they can inform our work on the ground.

While there is not much time for Q&A during the presentation sessions, we have designed the event with conversation in mind. The generous breaks and Stine Room layout are intended to create opportunities to ask questions of presenters and peers, challenge what you’ve heard, and explore ways to improve the resource conservation and management work that you do every day. **We hope you’ll consider the presentations the start of a conversation, not the last word.**

As usual, this year’s Review includes a large group of presenters. You will hear 20-minute presentations and 5-minute lightning talks throughout the day. The lightning talks are a brief way to get the big ideas across so that you can fill in the details during the breaks and poster sessions.

We're glad you joined us and we hope you enjoy the day!

-Eli Sagor and Madison Rodman
**Block 1**

*Ron Moen*
*University of Minnesota Duluth*
*rmoen@d.umn.edu, 218-788-2610*

**Climate-driven changes in future Minnesota mammal species**

Climate change is projected to increase mean annual temperature and precipitation in the Midwest. This will affect the distribution and abundance of mammal species in Minnesota. We used past trends in population size, climate envelope modelling, and recent observations to predict species responses to climate change in Minnesota. Because Minnesota is on the southern edge of the boreal forest and at the transition of prairie, northern hardwoods, and boreal forest, we will probably see more changes in mammal species than other areas. About half of current mammal species should still be present 50 years in the future. Example species include the short-tailed shrew, woodchuck, deer mouse, beaver, and white-tailed deer. About 20% of species will probably no longer be present, including Canada lynx, moose, American marten, and northern flying squirrel. About 20% of species should show a larger change in distribution within Minnesota; example species include the opossum, gray squirrel, skunk, and bobcat. Among the caveats to these predictions are that dispersal rates of smaller mammals could be limiting and that the magnitude of future climate change is unknown. Over the last 200 years we have already seen changes in the distributions and abundances of the other 10% of mammal species in Minnesota, and we are entering a future without a historical analog with respect to rate of climate change.

**Additional author names and affiliations:**
Steve K. Windels, Voyageurs National Park
Emerald Ash Borer and Black Ash: Wildlife Impacts

Emerald ash borers (Agrilus planipennis; EAB) cause near 100% mortality of ash (Fraxinus spp.) trees. Where they are the dominant species, loss of black ash (F. nigra) could result in black ash wetlands becoming emergent wetlands dominated by sedge. Our study uses a combination of experimental and control sites throughout northern Minnesota's black ash forests to examine the impacts of EAB on bird, mammal, and herptile diversity. The goals of our project are to: 1.) Assess wildlife species that utilize black ash wetlands compared to non-ash wetlands and upland forests; 2.) Determine how loss of ash will alter wildlife communities; and 3.) Identify vulnerable wildlife species and develop recommendations and strategies to maintain biodiversity. The project completed the first year of wildlife sampling and preliminary results will be discussed.

Additional author names and affiliations:
Josh Bednar, Natural Resources Research Institute, University of Minnesota Duluth; Nick Walton, Natural Resources Research Institute, University of Minnesota Duluth; Robert Slesak, Minnesota Forest Resource Council; Melissa B. Youngquist, University of Minnesota; Anthony D’Amato, University of Vermont; Brian Palik, USDA Forest Service Northern Research Station; Gerald Niemi, Natural Resources Research Institute, University of Minnesota Duluth
Enhancing the U.S. Forest Service Forest Inventory and Analysis database for supporting wildlife assessment: Implementation of U.S. National Vegetation Classification

The U.S. Forest Service Forest Inventory and Analysis (FIA) program maintains information on the status and trends of the nation's forests. FIA data and information have been used for conducting numerous wildlife habitat assessments, but there is no nationally consistent approach for linking FIA with wildlife species-habitat relationships. The U.S. National Vegetation Classification (NVC) Standard was adopted by the Federal Geographic Data Committee as a federal standard for reporting vegetation information across the United States (FGDC 2008). NatureServe and the U.S. Forest Service are collaborating to implement the NVC in the FIA Program. NVC uses an ecological vegetation approach that integrates ecological factors with all vegetation layers into an 8-level hierarchy of types. The mid-level types are practical for classifying the nation's forests using tree data collected on FIA “Phase 2” (P2) plots. For eastern U.S. forests, including Minnesota, NatureServe scientists completed a narrative-based key that uses available FIA attributes and tree species and life-history data to assign FIA P2 plot conditions to 27 macrogroup types and 11 plantation types. FIA analysts developed a computer algorithm based on this key, allowing for automated classification of each forested FIA condition. This key allows FIA to report data on eastern U.S. forests (and eventually all U.S. forests) using the NVC standard. The new FIA-NVC attributes will facilitate collaborations with other agencies using the NVC, and provide a consistent relationship between FIA and various wildlife species-habitat relationship matrices that use NVC, like those produced by NatureServe and GAP.

Additional author names and affiliations:
Shannon Menard, Don Faber-Langendoen, Kevin Nimerfro, Mark Nelson*, Mary Miller, James Garner  (Nelson is corresponding author and presenter)
Impact of Latent (hidden) Diplodia Infections on Planted Red Pine Seedlings

*Diplodia sapinea* is a common fungal pathogen of red pine. It can cause shoot blight, stem cankers, top-kill, and collar rot (image below), the latter of which frequently kills seedlings. There was a spike in shoot blight and latent (asymptomatic) Diplodia infections in Minnesota and Wisconsin state nurseries in 2016. The University of Minnesota determined that roughly 15 percent of bare root three-year-old red pine stock at Badoura State Forest Nursery had latent infections of Diplodia, so the crop was destroyed to avoid planting failures in sold seedlings. A subset of the bare root stock was reserved to analyze survival and determine if Minnesota DNR’s 10 percent threshold for latent Diplodia infection is appropriate. Bare root seedlings (n= 616) were planted at General Andrews nursery in spring 2017. One-year-old containerized seedlings (n=628) from a different nursery (PRT) were planted and assessed for latent Diplodia infection which was found to be zero. After one growing season, 61 percent of the bare root stock had died, and at least two-thirds of that mortality was estimated to be from Diplodia collar rot. Twenty-four percent of the containerized stock had died, and Cylindrocarpon root rot (sexual stage: *Ilyonectria radicola*) may have been a significant cause of that mortality (see table below). Forest Health staff will assess mortality through 2021. To date, it appears that Minnesota DNR’s 10 percent threshold for latent Diplodia infection may be appropriate and that lab analysis to determine latent infection may underestimate latency rates.

### Additional author names and affiliations:
Val Cervenka, Jessica Hartshorn, and Michael Parisio, Minnesota DNR

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<th>Cause of Death, 2017</th>
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<td>Cylindrocarpon</td>
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<tr>
<td>Diplodia</td>
<td>42</td>
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<tr>
<td>Phytophthora</td>
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<td>Poor Planting Technique</td>
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<tr>
<td>Unknown</td>
<td>18</td>
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<td><strong>TOTAL LOSS</strong></td>
<td><strong>61</strong></td>
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Effects of Alternative Silvicultural Methods on Black Spruce Tree and Stand Dynamics

The black spruce cover type covers roughly 10% of Minnesota’s 17.4 million acres of forestland. A high percentage (85%) of the resource is nearing, currently achieving, or exceeding typical rotation ages. Eastern spruce dwarf mistletoe (Arceuthobium pusillum) can cause significant mortality in black spruce, and is causing significant management concerns in portions of Minnesota. Black spruce is typically managed using even-aged silvicultural systems (clear-cutting and variations), and the effects of managing with alternative systems remains largely understudied. Understanding a breadth of management options may help managers be able to target increased growth and achieve optimal future stand conditions. The Compartment Study was established by the USDA Forest Service in 1948 to assess how lowland black spruce stands respond to six silvicultural treatments (clear-cut strips, clear-cut patches, shelterwood, thinning, individual tree selection, group selection). The treatments and a control were installed, treated, and measured in 1950, with additional measurements occurring five and ten years later. Ten-year diameter growth was found to be significantly affected by treatment, and trends were found in tree mortality in varying treatments. A growth model predicting individual tree diameter growth was adapted from previous work and fit to 10,244 observations. The results suggest that using alternative silvicultural systems in managing Minnesota’s black spruce forests may have merit, but trade-offs exist when selecting a silvicultural system. A subset of treatments (shelterwood, clear-cut strips, clear-cut patches) were remeasured in summer, 2017. Analysis is in progress to assess long-term effects on stand-level dynamics, and preliminary results are also presented here.

Additional author names and affiliations: Marcella Windmuller-Campione (U of MN), Matthew Russell (U of MN), Brian Palik (USFS North Central Research Station), Douglas Kastendick (USFS North Central Research Station)
LiDAR Derived Topographic Riparian Areas
Utilizing LiDAR Digital Elevation Models to Produce Variable Width Riparian Areas

Restoration and construction of riparian buffer zones provide adequate shading along cold and cool water streams. In addition, riparian areas reduce heavy runoff of non-point source pollution and sediments, which is directly related to the key strategies of the Lake Superior Climate Change Impacts and Adaptation report’s plan to manage habitats, species, and ecosystem function. The Lake Superior Biodiversity Conservation Strategy also strives to restore and protect self-sustaining Brook Trout populations in as many of the original native habitats as practical by establishing forested riparian areas for shade and long term wood recruitment. To determine proper placement of riparian buffer zone boundaries, technical analyses of topographic datasets is essential. This poster details the generation of variable width topographic riparian areas from LiDAR derived digital elevation models and is used to characterize the extent of wetlands along stream corridors for better management practices. LiDAR derived Next-Generation Hydrography products and digital elevation models were utilized as inputs to produce polygons which represent riparian features that directly impact the flow and connection of surface waters across the landscape. The resulting variable width topographic riparian areas can then be used to manage the restoration and construction of riparian buffer zones and improve the overall health of the watershed.

![Figure 1) Lidar derived variable width riparian area boundaries are more aligned with localized topography and are better represent the way surface waters flow across the landscape. On the left is the results are overlaid on a Hydrologic Position Index and on the right the results are overlaid on NAIP 2015 imagery.](image)
First-Year Effects of Biochar and Weed Control on Jack Pine (*Pinus banksiana*) Survival and Growth

More intense and frequent droughts have been negatively impacting the growth and survival of jack pine (*Pinus banksiana*) seedlings planted on the Superior National Forest in northern Minnesota. Biochar is a bio-based soil amendment that can increase soil fertility, forest productivity, and resilience to drought conditions associated with a changing climate. We initiated a study to determine whether the addition of a biochar or compost amendment to the soil will alter the water-holding capacity of the soil to allow for increased seedling growth and survival during droughty summer conditions. At three different locations in the Superior National Forest, jack pine seedlings were planted in the spring of 2016 in a randomized 2-way factorial design. Factor 1 was soil amendment (biochar, compost, a biochar-compost mix, and a control) and Factor 2 was a weed control treatment where competing vegetation was mechanically removed once during the growing season. Here, we present treatment effects on growth and survival in the first year after the seedlings were planted. Measurements will continue in future years and we expect that the results will contribute to landowner and land manager considerations associated with the survival of jack pine (or other species) in the changing climate. Information generated from this study will be used to assess trade-offs of biochar use as a forest management tool.

Additional author names and affiliations:
Robert Slesak, Dept of Forest Resources; Marcella Windmuller-Campione, Dept of Forest Resources
Coastal Adaptations: Forests and Freshwater

Forests of the Great Lakes region will likely experience some of the most dramatic changes in the continental US in response to climate change. Today’s coastal forests are vulnerable to declines in signature canopy tree species, including paper birch, quaking aspen, balsam fir, and white spruce. Sustaining flows and water quality in streams and rivers of Lake Superior’s coastal zone will require climate-adapted approaches to forest management to maintain and enhance forest cover under changing climatic conditions. For 6 HUC10 watersheds (22 HUC 12 watersheds), we used LANDIS II to compare forest cover and composition under “Business as Usual” (BAU) forestry practices vs. “Climate Adaptive Silviculture” (CAS). Modeling results (from 2000-2100) showed a strong trend across all watersheds with a steep decline of boreal species and corresponding increases in temperate species. Although trends are similar under both management scenarios, CAS maintained higher overall biomass and diversity than BAU. We calculated a relative resilience index for each HUC10 watershed, and found that the northern watersheds scored higher—perhaps as a result of cooler temperatures which also help to maintain boreal species even as temperate species increase. We compiled data from multiple sources to characterize the relative resilience of stream networks in each watershed, which followed similar trends as the uplands (from North to South). Our findings underscore the importance of adapting forestry practices to address climate change impacts to sustain values in both terrestrial and aquatic ecosystems. (NOAA Award Number: NA16NOS4190119/MLSCP Project Number:16-306-10)

Additional author names and affiliations:
Kristen Blann (The Nature Conservancy) and Mark White (The Nature Conservancy)
Assessing quaking aspen stress and mortality along a climate gradient in Northern Minnesota

Since quaking aspen are an important tree economically and ecologically in Minnesota, it is important to understand current mortality patterns with respect to drought and climate change.

In this study, we assessed the health of 69 Minnesota aspen stands via transect sampling in the ecotone regions of the four botanical provinces around Bemidji: the laurientian mixed forest, the eastern broadleaf, the tallgrass aspen parkland, and the prairie parkland province. It was found that regions sampled in the tallgrass aspen parkland had the lowest mortality rates, closely followed by laurientian mixed forest and then eastern broadleaf. The prairie parkland province was found to be the least healthy, having the highest percentage of severely stressed aspen.

With the current precipitation gradient from eastern to western Minnesota, a shift to decreased rainfall due to climate change could transition central Minnesota aspen stands into stands with stress characteristics similar to current western Minnesota aspen stands.

We are currently using time domain reflectometry dataloggers to ground truth Soil Moisture Active Passive (SMAP) data to analyze the impact of soil moisture on aspen stand health among the ecoregions. While preliminary results comparing SMAP, rainfall, and soil moisture data at 10 cm and 50 cm depth showed generally good agreement for July and August 2018, when the SMAP and TDR data was detrended the residuals showed a fairly low agreement.

Along with testing methods of ground-truthing SMAP data with TDR dataloggers in the field, we are evaluating the use of high resolution (10 m) Sentinel NDVI to better model patterns of aspen health and mortality by comparing it with field assessments of aspen stands. Preliminary results have shown a weak positive correlation in the eastern broadleaf and the prairie parkland and weak negative correlations in the tallgrass aspen parkland and laurientian mixed forest.

Additional author names and affiliations:
Ryan Ness 1, Greg Liknes 2, Jillian Walechka 1, and William Sea 3
1 Graduate Program in Environmental Studies, Bemidji State University
2 Northern Research Station, U.S. Forest Service, St. Paul
3 Center for Environmental, Economic, Earth and Space Studies
Inventory of Northern White-Cedar Regeneration and Factors Affecting Seedling Establishment and Growth

Regeneration of northern white-cedar (Thuja occidentalis) has long been a challenge for foresters in Wisconsin and throughout the Upper Great Lakes region. Northern white-cedar is browsed heavily by deer and requires a specific seedbed for seedling establishment. The objective of this research was to inventory regeneration of northern white-cedar in northern Wisconsin across a range of deer densities, along with a range of stand and seedbed conditions (Fig 1).

Preliminary results showed low densities of cedar regeneration across the study, but regeneration did significantly vary between study sites. While cedar regeneration was not related to county-level deer densities, increasing stand-level deer browsing had an impact on cedar regeneration. Stand-level deer impacts may be more important to understanding cedar regeneration than county-level deer estimates, but are harder to quantify and manage for.

Initial results indicate that browsing, competition from other seedlings, overstory stem density, and soil variables may all have significant impacts on white-cedar seedling establishment and recruitment into taller size classes. Our data indicate the complex array of factors that affect cedar regeneration. The results from this analysis are being used to develop a northern white-cedar regeneration manipulation study that will further examine the impacts of deer, seedbed, and competition on northern white-cedar regeneration and inform managers and landowners looking to regenerate cedar for wildlife and wood products.

Additional author names and affiliations:
Teresa Pearson, Wisconsin DNR; Laura Kenefic, USDA Forest Service Northern Research Station; Christel Kern, USDA Forest Service Northern Research Station; Dustin Bronson, Wisconsin DNR

Figure 1. Location of study sites in Wisconsin. Sites are named after the county in which they occur. Counties shaded in green show the distribution of northern white-cedar stands in Wisconsin, per FIA data.
Temperature and water level effects on greenhouse gas fluxes from black ash wetland soils

Forested black ash wetlands are an important economic, cultural, and ecological resource in the northern Great Lake States, and are threatened by the invasive insect, emerald ash borer (EAB). EAB-induced ash dieback can modify wetland hydrology by elevating the water table, and increase air temperature following canopy dieback. Changes in water table levels and temperature may alter gaseous fluxes of carbon and nitrogen from wetlands, but the relative magnitude of changes is unclear. We incubated soil cores from black ash wetlands with mineral and organic soils, and measured the efflux of carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O) at different temperature and water level treatments. Mean CO₂ fluxes were greatest under the warmest conditions, but soil type and water level treatments did not have a significant influence. The saturated organic soil cores had significantly higher CH₄ fluxes. Mean N₂O fluxes were significantly greater in the saturated, mineral soil cores. Gas fluxes generally increased and became more variable with temperature, and treatment effects were amplified at warmer temperatures. Elevated water tables in mineral soil black ash wetlands would result in greater N₂O fluxes and export of nitrogen from the ecosystem. In organic soils, elevated water tables in black ash wetlands would result in greater CH₄ fluxes and carbon release into the atmosphere. Increased soil temperature will lead to greater gaseous fluxes in both wetland ecosystems. Our findings demonstrate potential indirect effects of EAB in black ash wetlands, with implications for ecosystem functions associated with C and N cycling.

Additional author names and affiliations:
Robert Slesak: Minnesota Forest Resources Council, St. Paul, MN
Randall Kolka: USFS Northern Research Station, Grand Rapids, MN
Rodney Venterea: USDA Agricultural Research Service, St. Paul, MN

Figure 1: Carbon dioxide fluxes increase with temperature, but have no clear relationship with soil type or water level treatment.
**Figure 2:** Nitrous oxide gas fluxes are greatest in the completely saturated mineral soils (solid red line) indicating that mineral soil black ash wetlands (common in Minnesota) experiencing higher water tables and warmer temperatures following EAB infestation, will have an increasing loss of nitrogen to the atmosphere.

**Figure 3:** Methane fluxes are greatest in the saturated peat soils (solid blue line) indicating that black ash peatlands (common in Michigan's Upper Peninsula) will experience greater loss of carbon and become a greater source of methane with rising water levels and increasing temperatures following EAB infestation.
Experiencing the effects of timber management on water quantity and water quality in the Upper Midwest

The combination of extensive surface water coverage, low topographic relief, and landscapes of mixed upland and lowland ecosystems throughout the Upper Midwest results in unique relationships between timber management and surface water quantity and quality. While much of the previous work examining these relationships has been conducted at the scale of small (< 100 acre) watersheds and first-order streams, timber harvests and the watersheds in which they occur are often much larger in scale. We will present preliminary results of an ongoing study examining the effects of a 100-acre growing season upland aspen harvest on water quantity and quality in the West Swan River (St. Louis County, MN). The watershed contributing area for the West Swan River study site encompasses approximately 80 mi² of both upland forest and lowland woody wetlands. We will discuss the importance of spatial scale when considering the effects of timber management on water quality, as well as the extreme hydrologic and biogeochemical variability of this system at both seasonal and event time scales.

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Forest loss in Minnesota since European settlement

A significant amount of forest lands have been converted to agricultural and urban land uses in Minnesota. This poster will present a high resolution map of those conversions. Contemporary land uses, as measured by the National Land Cover Dataset, will be compared to Marschner’s presettlement vegetation.
Ten Years Post-Harvest: Results from the Wisconsin Northern Hardwoods Managed Silviculture Study

In 2007 the Wisconsin Managed Silviculture Study was initiated to test varying northern hardwood silviculture harvest strategies. Three stand locations were selected across Wisconsin’s northern hardwoods cover type. Harvests treatments included single tree selection, group selection of both 60- and 80-ft diameter gaps, and irregular shelterwood. All group selection harvests had a nested treatment of either uncleaned gaps, cleaned gaps, or scarification. All treatments included nested deer exclosures to test the effect of white-tailed deer browsing. We will present the tree regeneration study results ten years after harvest. We will discuss how varying harvest strategies affect species diversity, stem density, and height growth. Additionally, we will discuss the effect of deer browse on species diversity and height growth.

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Forest management for multiple objectives: adaptation, timber production, and wildlife silviculture case studies at the Cloquet Forestry Center

"Silviculture deals with the methods for establishing and maintaining healthy communities of trees and other vegetation that people deem important" (Nyland 2016, "Silviculture: Concepts and Applications"). What “people deem important” shifts based upon society's needs and desires and the biases of land managers. This presentation introduces the TRIAD conceptual framework influencing my approach to forest management, highlights three silvicultural prescriptions at the Cloquet Forestry Center, and discusses the lessons learned through their implementation. The TRIAD encourages incorporating areas of Intensive, Extensive, and Reserve management into one’s management portfolio. The “Zebra” prescription aims to produce red pine timber using a strip-seedtree natural regeneration silvicultural system. Two Extensive management examples include the “FAPP” (Forest Adaptation Planning and Practices) prescription developed with the primary goal of diversifying stand composition and structure to increase adaptive potential and the “Fisher” prescription developed to promote fisher habitat. Key lessons learned about management for multiple objectives are 1) Don’t do the same thing everywhere, 2) Work with the stand’s features when developing objectives, and 3) Think outside the stand.
Lake States Maple Syrup Producers and Their Attitudes Towards and Responses to Economic, Social, Ecological, and Climate Challenges

Maple syrup is an iconic as well as economically and culturally important non-timber forest product. However, maple syrup producers are facing a diversity of challenges, including: potential range shifts in the maple resource; increasing variability in the timing, duration and yield of operations; invasive species, pests and diseases; intergenerational land and business transfer challenges; high equipment costs; and regulatory issues. We examine the challenges that maple syrup producers in MN, MI, and WI are facing, strategies they are taking, and assistance they need to help them in maintaining their operations and sugarbush.

While many respondents indicated they have undertaken or plan to undertake adaptation activities (e.g., active management for healthier or more productive trees), only 11% had done so out of specific concern over climate conditions. Climate-motivated activities generally included: being prepared to tap earlier and utilizing newer technology to enhance sap collection and processing efficiency. Respondents were generally unlikely to consider planting climate-resilient maple cultivars or tapping trees other than sugar maple. They expressed the greatest concerns over the health of their trees and forest pests, as well as their physical ability to continue their operation and having family members interested in continuing the operation. Boil season variability and weather issues were viewed with less concern. Respondents were generally optimistic that they can adapt to future conditions, likely in large measure through the adoption of new technologies, and expect their syrup production levels to slightly increase in the future.

To account for differences associated with one’s size of operation, the data were divided into three producer size categories based on the number of taps used in the 2016 season. Small producers (S) were defined as those with less than 100 taps. Medium size producers (M) were defined as those having between 100 and 1000 taps. Large producers (L) were defined as those with greater than 1000 taps.

Producers were provided a list of factors related to the future of their sugaring operation, and asked to rate their level of concern from 1 (No Concern) to 5 (Significant Concern). Average ratings were computed for each producer size class. When examining responses over all producer size classes, tree health rated the highest factor of concern (Figure 1).
Producers were asked to consider seven information/training topics and rate their importance on a scale of 1 (not important) to 5 (very important). Based on mean values, the topic of greatest interest among all respondents was tree health, followed by information on improving profitability of one’s sugaring operation (Figure 2).
Seedling Response to Adaptive Silviculture Treatments Aimed at Climate Change in Northern Minnesota

Future climate change is expected to impact the health and productivity of forests in northern Minnesota. Forest managers are facing increasing challenges to maintain and sustain forests in the face of high uncertainty associated with response to climatic changes. The Adaptive Silviculture for Climate Change (ASCC) project was developed to provide operational-scale research opportunities to assess, demonstrate, and test adaptive forest management approaches. The silvicultural treatments are specifically designed to represent a gradient of adaptation approaches that include resistance, resilience, and transition, achieved through different combinations of harvesting, site preparation, and regeneration, both artificial and natural. The first of five ASCC installations is located on the Cutfoot Experimental Forest-Chippewa National Forest. As part of the transition and resilience treatments, nine tree species were planted based on predicted suitable habitats under future climate change. Of particular interest is initial seedling performance of future climate-adapted species, with an emphasis on understanding the environmental characteristics that may contribute to their success. To study this, we quantified below-canopy microclimate within the adaptation treatments over the course of two growing seasons, including hourly measurements of soil temperature, soil moisture, air temperature, and relative humidity, along with estimations of leaf area index (LAI) and photosynthetically active radiation (PAR). Seedling performance was tested against microclimate variables across the treatments to better understand the environmental mechanisms behind individual species response to the adaptation treatments. This presentation will highlight the variability of microclimates across the treatments and associated canopy structures, the environmental mechanisms driving seedling growth and survival, and the initial performance of future climate-adapted species in northern Minnesota forests.

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A 2016 Profile of Minnesota Logging Business Owners

Minnesota logging business owners who are members of the MN Logger Education Program were surveyed in 2017 to collect and update information on the status of Minnesota’s logging sector. Data were collected across a broad suite of areas for a respondent’s business operations in 2016, including production levels, stumpage sources, equipment mix, and profitability. Many comparable questions were asked in previous surveys. In addition, new questions were asked to understand use of technology and salvage harvesting activities. Based on 140 useable survey responses (overall response rate of 39.4%), some of the key findings are noted below.

- The average Minnesota logging business harvested 11,267 cords (median was 4,000 cords) and has been in business 30.5 years.
- The twenty-three highest volume producing companies (those who produced more than 15,000 cords and comprise 18% of the respondents) harvested 68% of the reported volume and the 73 smallest producers (those who produced ≤ 5000 cords and comprise 56% of the respondents) harvested 9% of the total volume (Figure 1).
- Approximately 72% of the stumpage harvested was purchased by respondents. Respondents reported controlling about half of their stumpage within the current year as compared to longer periods into the future.
- Seventy-four percent of the volume was felled using a feller-buncher and 16% by a CTL harvester.
- Fifty-three percent of the volume was harvested during the winter, an increase from the 2011 (51%) and 1991 (43%) surveys. The average business operated during three seasons. Equipment repair and maintenance, livestock production, farming crops, construction and road building were most commonly cited as other activities conducted by respondents when they didn’t harvest timber.
- State and county land departments provided 51% of the volume harvested.
- About 42% of the respondents harvested wood from salvage sales in 2015 or 2016. For those who did harvest salvage sales, nearly 90% of respondents reported reduced in-woods productivity and a reduction in wood quality and 72% reported higher levels of safety concerns and increased impacts to their equipment.
- 98% of respondents who had harvested wood from salvage sales reported that it took longer to operate in a sale affected by a severe windstorm as compared to a non-salvage operation. 58% indicated that it took the same amount of time to operate in a sale affected by an insect or disease attack as compared to a non-salvage sale. 51% reported that it took longer to operate in a sale affected by a recent fire as compared to a non-salvage sale.
- Businesses which produce up to 10,000 cords annually continue to replace their equipment less frequently than higher volume producers. Twenty-nine businesses (21% of
respondents) plan to purchase equipment to expand their business within the next three years.

- Seventy-six percent of respondents plan to maintain or increase their volume harvested in the future. Forty-two percent indicated that their profitability was better in 2016 than in 2013 and 39% indicated that their profitability was good or excellent in 2016.
- Only 20% of the respondents indicated that they would encourage a family member or close friend to become a logger.
- Twenty-seven percent of respondents don’t expect to be in business in five years, primarily due to the age of the business owner(s).
- While 41% of the respondents indicated that a family member is likely to take over their business in the future, 56% don’t know if anyone will take over their business.
- While approximately thirty-five percent of respondents indicated that they operated at full capacity during 2016, 69% of CTL businesses indicated that they operated at full capacity. The average business that didn’t operate at full capacity estimated they could have produced 5,392 additional cords with 45% of the volume during the summer.
- Use of electronic technology is important in many respondents business operations, with 94% of respondents reporting use of a smartphone and 74% use of high speed internet at least once a day for business use.

Figure 1. Annual volume harvested (cords) in 2016 by number of responding businesses and percent of total reported volume harvested.
Minnesota Breeding Bird Atlas

The Minnesota Breeding Bird Atlas (MNBBA) was a 5-year project (2009–2013) completed by > 800 volunteers and paid researchers with the goal of documenting the distribution and abundance of Minnesota’s breeding birds. The results of the MNBBA are now available online at https://mnbirdatlas.org/. In addition to the general atlas results, the site includes natural history and conservation status for all 249 species detected during the atlas, species distribution models for 115 species, and statewide population estimates for 66 species. This is the most comprehensive aggregation of information on the current status of Minnesota’s breeding birds. Here, we present on species distribution models, population estimates, and overall use of the MNBBA website. We derived species distribution models using either MaxEnt or General Linear Models (GLMs). For 66 passerines, we extended the GLM using an offset to account for detectability and thereby make predictions of species density and statewide population estimates. The MNBBA used an interactive web map to present species distribution models and general atlas results, allowing users to explore the species use of Minnesota as their needs dictate. We anticipate this will be useful for a variety of applications including land management, conservation, bird watching, and consideration on climate change issues.

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Does Wildland Fire Cause Increases in Mercury in Fish?
We investigated the effects of wildland fire on young-of-the-year yellow perch and lake chemistry in the Boundary Waters Canoe Area Wilderness. Wild and prescribed fire can alter mercury cycling on land and in adjacent aquatic environments. In addition to enhancing local atmospheric mercury deposition, fire can influence terrestrial movement of mercury and other elements into lakes via runoff from burned upland soil. However, the impact of fire on water quality and the accumulation of mercury in fish remains unclear. While some studies have observed a significant increase in fish mercury following forest fires, others observe no significant effect.
We found:
Wildland fire decreased upland organic soil mercury stocks by 19% and carbon stocks by 26%, on average.
No impact of low to moderate severity wildland fire on lake chemistry or fish mercury. Climate and lake parameters, not wildland fire, explain inter-annual variation in lake productivity and fish mercury bioaccumulation.

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A foundational data set characterizing historic forest attributes and disturbance patterns

Forest disturbance dynamics (arising from harvest, fire, wind, land conversion, etc.) play a fundamental role in the health and resilience of multiple forest resources including water quality, wildlife habitat, and wood resources, among others. Long running satellite sensors such as Landsat are expanding opportunities to monitor forest trends through time, improving our understanding of forest disturbance and recovery patterns. Our project utilizes the full value of the Landsat archive by harmonizing and incorporating imagery dating back to 1973 to provide >40 years of comparable inter-annual trends in forest dynamics across the state of Minnesota.

Figure 1. The two main steps involved in compiling the base dataset of comparable spectral indices through time include the harmonization of the imagery across all Landsat sensors (via the LandsatLinkr R package; http://dx.doi.org/10.5281/zenodo.807733) and the smoothing of additional year-year spectral noise to better represent forest change dynamics (LandTrendr segmentation algorithm; http://landtrendr.forestry.oregonstate.edu/).

In this presentation, we demonstrate a variety of applications that this foundational data set can support including forest change detection and disturbance agent attribution (e.g. harvest vs. windthrow), statewide annual maps of forest canopy cover (1973-2015), and habitat change assessments for wildlife species of management and conservation interest. These applications and related data products are just the beginning of the many valuable products that can be extracted from the foundational time series data set that spans a greater than 40 year period. We plan on periodically updating this forest disturbance time series in the future, which will provide unprecedented spatial and temporal data products to help inform ongoing and future forest and wildlife management. We are currently working with some wildlife ecologists and forest managers...
on specific applications, and hope to engage with the broader natural resource community to utilize the full potential of this incredible data set.

Figure 2. Annual statewide canopy cover maps from 1973-2015 is an example of forest attribute products created using our foundation time series data set.

Figure 3. Utilizing our time series data set, we are creating multiple disturbance mapping products. One example is a map of the most recent fast disturbance which we have classified by agent of change. In addition to the above example, we are also creating classified maps of annual fast disturbances from 1975-2015.

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Urban Tree Canopy Mapping and Measuring using High-Resolution Remotely Sensed Data

Urban tree canopy is a critical and rapidly changing component of the city landscape. Tree canopy provides benefits that range from ecological to economic to aesthetic. Obtaining landscape scale information on the status of tree canopy is costly and time-consuming on the ground but can be completed much faster and more cost-effectively from the air. In this research, we used airborne remotely sensed data to precisely observe the abundance, condition, and changing status of urban tree canopy. High-resolution optical imagery and lidar datasets were used in combination to update and assess change of urban tree canopy in the seven county Twin Cities Metropolitan Area. Object-based image segmentation using eCognition software was able to automate detection of isolated tree crowns.

Exploration of new lidar point cloud interpolation methods enabled three-dimensional measurements of the canopy structure to be calculated for each detected object. Lidar provides another dimension for monitoring urban forest canopy abundance as well as detection of changes in canopy coverage. LAStools suite of point cloud processing tools was used to obtain structural measurements useful for measuring urban tree canopy. Parsing this data into useful information for large areas was achieved by modeling the point cloud as a normalized raster height model. Next, eCognition’s multiresolution segmentation algorithm was applied to create discrete and measurable image objects that represent
features in the landscape. This work shows how physical measurements, such as total height, crown height, crown area, and crown volume, can be calculated for individual tree crown objects. The average tree height was found to be 16.7 meters tall within the study area. Urban trees in St. Paul were approximately one meter taller on average than trees in Minneapolis. The distribution of tree heights across the urban area provides a unique quantitative insight that is otherwise unknown at the city scale. 2D extracted land cover vector layers, in addition to the 3D lidar measurements, are combined into a suite of extracted layers that are used to describe the state of the urban forest.

Remote sensing is a powerful tool for monitoring landscape change as well as composition. Assessment of land cover classification difference between 2009 and 2015 found that 3.5% of the landscape in Minneapolis and Saint Paul changed from tree canopy to paved surface. Tree canopy loss was widespread across both cities but most often occurred on residential streets. The causes of tree canopy loss are from both man-made and natural sources. Man-made sources of canopy loss include street tree removal, road construction, and other urban landscape alterations. Natural sources include wind blowdown events, tornados, and pest damage. The resulting geospatial data layers are available in an ArcGIS online webmap to provide access to valuable geospatial information to the community and gain insights on how change in urban tree canopy impacts the landscape. This demonstrates the value of remotely sensed data for monitoring and assessment of tree canopy and encourages support of more frequent collection of remotely sensed data.
Poster only

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Methylmercury Accumulation in Wildlife in an Upland Forest-Peatland Habitat

Methylmercury (MeHg) can bioaccumulate in wetland food webs and cause health impacts at low concentrations to both humans and wildlife. MeHg is often elevated at the terrestrial–peatland interface, but methylmercury production at this “hot spot” in peatlands has not been linked with bioaccumulation in food webs. We examined total mercury (Hg) and MeHg levels in peat, invertebrates, and tissues of the insectivore *Sorex cinereus* (masked shrew), inhabiting a northern Minnesota terrestrial–peatland ecotone exposed only to atmospheric deposition of Hg. Invertebrate MeHg concentrations followed trophic position in the food web with highest concentrations measured in predaceous spiders (mean 70–140 ng/g) and ground beetles (mean 42 ng/g), followed by lower concentrations in detritivorous millipedes (mean 29 ng/g) and worms (mean 11 ng/g). Mean MeHg concentrations in juvenile shrews (71 ng/g) were similar to MeHg concentrations in top invertebrate predators. Methylmercury concentrations in shrews increased with age and differed among tissues, with highest concentrations in kidneys and muscle, followed by liver and brain. Nearly all Hg in shrews was in the methylated form. Overall, the concentration of MeHg in invertebrates and shrews at the site fell below values considered a toxicological risk and suggest that MeHg transfer from peatland to terrestrial systems via invertebrates or shrews is unlikely without Hg point sources or nearby large emissions.

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Mapping of Black Ash Forest Threatened By Emerald Ash Borer In Northern Minnesota, USA

The introduced emerald ash borer (EAB; *Agrilus planipennis* Fairemaire) has been a persistent disturbance on ash forests in the United States since 2002 and is advancing into northern portions of the Upper Midwest. Of particular concern is the impact EAB will have on the ecological and hydrological functioning of wetlands dominated by black ash (*Fraxinus nigra*). In preparation, forest managers need reliable and complete maps of the spatial configuration, extent, and distribution of black ash. Traditionally, the Forest Inventory and Analysis (FIA) program has provided rigorous measures of tree species presence at large scales but is limited with regard to small area estimation. Fortunately, the use of remotely sensed data can spatially extend forest survey information collected by FIA to estimate and predict forest attributes at fine resolutions. We integrated spectral and topographic indices from remotely sensed datasets with FIA data in a classification algorithm (randomForests) to predict black ash presence in northern Minnesota, USA. Model selection techniques were employed to optimize ecological interpretability and model parsimony. Additionally, we downsampled the majority class to n * minority to minimize the effect of imbalanced learning. The final model produced low error rates (Overall: 14.5%, Presence: 14.3%, Absence: 14.6%). The modeling results provide forest managers with detailed maps of black ash presence, which can ultimately be used to help guide forest planning and management of forests at risk of emerald ash borer invasion.

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**Individual detection and plot-wide estimation of coarse woody debris density and volume using airborne LiDAR**

Coarse woody debris (CWD) is an important habitat component for many forest wildlife species. CWD also plays an important role in nutrient cycling in forest ecosystems and serves as potential fuel for wildfires. CWD detection and mapping would enhance forestry and wildlife research and management, but field-based CWD inventories are not practical for mapping CWD over large areas. Light detection and ranging (LiDAR) is an active remote sensing technology that provides detailed information on three-dimensional vegetation structure over large spatial extents. Our objectives were to evaluate the ability of LiDAR to detect individual pieces of CWD and to estimate plot-wide CWD density and volume. We acquired high-density (8 pulses/m²) LiDAR data in 2014 and measured 1,968 pieces of CWD at 189 forest inventory plots from 2015-2016. We filtered out canopy and sub-canopy returns in an attempt to improve model accuracy compared to previous attempts to model CWD using LiDAR. We detected 23% of the individual pieces of CWD, and larger pieces of CWD were more likely to be detected. We will present results of statistical models aimed at estimating plot-wide estimation of CWD density and volume.

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And finally, without your registration and participation, the event would have been significantly less interesting. Thank you for joining us today.

-Eli Sagor and Madison Rodman
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