2019 Science Symposium

April 8 – 9, 2019

Duluth, MN

The Heart of the Continent
Ontario, Canada • Minnesota, U.S.A.

The Heart of the Continent
Ontario, Canada • Minnesota, U.S.A.

Welcome to the Heart of the Continent Partnership's Science Symposium! We are excited to share this opportunity to learn, communicate, and collaborate about the role of science in managing the Heart of the Continent.

The Heart of the Continent Partnership (HOCP) is a Canadian/U.S. coalition of land managers and local stakeholders working together on cross-border projects that promote the economic, cultural, and natural health of the lakes, forests, and communities within the 5.5 million acre (2.2 million hectare) landscape.

This ecosystem encompasses separately managed natural areas, including Quetico Provincial Park, Superior National Forest (including the Boundary Waters Canoe Area Wilderness), Voyageurs National Park, Grand Portage National Monument and numerous Minnesota state forest lands and parks and Ontario provincial parks.

The Science Symposium strives to: 1) Improve understanding of natural and cultural resources across the HOCP, 2) Raise awareness of threats and management challenges to those resources, and 3) Promote collaboration among scientists, managers, and other stakeholders across political, cultural, and administrative boundaries so that resources can be better managed in a landscape context.

We look forward to learning, communicating, and collaborating with you during this and (hopefully) future events!

Sincerely,

Science Symposium Organizing Committee

Acknowledgements

Shannon Barber-Meyer

Gary Davies

Bob DeGrosse

Jesse Engebretson

Doug Franchot

Craig Hansen

Brian Jackson

Tonia Kittelson

Jamie LeDuc

Molly MacGregor

Sarah Malick Wahls

Lisa Radosevich-Craig

Ingrid Schneider

Ann Schwaller

Brandon Seitz

Brian Sturtevant

Reconstruction of Paleoenvironmental Conditions and Temporal Patterns of Ancient Mining on Isle Royale using Biogeochemical Analyses of Lake Sediment

Kathryn G.Vall, Earth and Environmental Sciences, Large Lakes Observatory, University of Minnesota Duluth, 1049 University Dr, Duluth MN 55805, vallx005@d.umn.edu, 701-793-0048

Byron A. Steinman, Earth and Environmental Sciences, Large Lakes Observatory, University of Minnesota Duluth, 1049 University Dr, Duluth MN 55805, bsteinma@d.umn.edu

David P. Pompeani, Department of Geography, Kansas State University, Manhattan, KS 66506, dpomp04@gmail.com

Kathryn M. Schreiner, Chemistry, Large Lakes Observatory, University of Minnesota Duluth 1049 University Dr, Duluth MN 55805, kschrein@d.umn.edu

Seth DePasqual, Cultural Resources, Isle Royale National Park, 800 E Lakeshore Dr, Houghton MI 49931, seth_c_depasqual@nps.gov

Isle Royale and the Keweenaw Peninsula of Michigan are home to some of the oldest examples of native North American metalworking and land use. This research aims to produce a reconstruction of the timing, spatial patterns, and environmental impacts of mining activities on Isle Royale through sedimentological and biogeochemical analysis of lacustrine sediments. We also seek to produce a parallel record of paleoenvironmental conditions to assess the potential impacts of environmental change on ancient mining cultures.

Lily Lake, on Isle Royale, MI, has been exposed to very little human land use change relative to other lakes on the island (e.g. there are no ancient mine pits in the immediate catchment), thus is well suited for reconstructing past environmental changes. Preliminary results from the metals analysis of bulk sediment from Lily Lake provide evidence of Middle Archaic mining activity that is temporally consistent with radiocarbon dated artifacts from other lakes located adjacent to ancient mine pits on Isle Royale and the Keweenaw Peninsula of Michigan. Additional work is required to assess the relative influence of natural versus anthropogenic processes that may have influenced metal concentrations in Lily Lake sediment and to determine a transport mechanism for the putative mining related pollution.

Poster Session

Monday, April 8, 2019

7:00 p.m. to 9:00 p.m.

- Dovetail Café -

1917 W Superior Street

Duluth MN 55806

* *The Science in Scientific and Natural Areas: Selected examples of research done in northeast Minnesota SNAs*
* *Spatial Variability of Mercury in the St Louis River Watershed across Four Landscape Types*
* *Summary of mist-netting surveys for bats on the Superior National Forest 2013-2017*
* *NRRI Impacts of Emerald Ash Borer on Bird Communities*
* *Restoration approaches in Vaccinium-dominated landscapes*
* *Highlights of the 2017 Quetico Provincial Park Angling Survey*
* *Red & White Pine Ecosite Relationship with Implications for Long Term Persistance in Absence of Fire in Quetico Provinicial Park*
* *Technologies and Management Practices to Reduce Impacts of Light Pollution on Environmental and Human Health*
* *Lead Pollution from Prehistoric Copper Mining on Southwest Side of Isle Royale.*
* *Minnesota Department of Natural Resources and the Watershed Restoration and Protection Strategies and One Watershed, One Plan Programs*
* *Sensitivity Analysis of Canopy Fuel Loads on Crown Fire Behavior in Northeast Minnesota*
* *Mapping Forest Canopy Bulk Density in the Superior National Forest to Support Fire Behavior Modeling*
* *Reconstructing Historical Forest Composition and Abundance by Using Archived Landsat and National Forest Inventory Data*
* *Evaluating the Impacts of Environmental Factors on the Eastern Larch Beetle in Minnesota*
* *Hill Annex Paleontology Project: Research into the Cretaceous deposits of Minnesota*
* *Genetic structure and hybridization in North Shore populations of two arctic relict plant species: Euphrasia hudsoniana and Primula mistassinica*

Poster Abstracts

The Science in Scientific and Natural Areas: Selected Examples of Research Done in Northeast Minnesota SNAs

Bjorklund, Lindsay, Interpretive Naturalist, Division of Ecological and Water Resources, MN DNR, 7979 Hwy 37 Eveleth MN 55734, (218)735-3971, lindsay.bjorklund@state.mn.us

The Scientific and Natural Areas Program preserves Minnesota's natural heritage (ecological and geological diversity maintained for present and future generations) for scientific study and public understanding. This natural heritage includes: native plant and animal communities, rare species, places of biodiversity significance, geological features/formations, and other natural features/formations. The SNA program encourages research and educational pursuits to advance the knowledge of natural systems.

This poster will visually represent and briefly summarize four to eight selected research studies that have occurred in the past on SNAs in northeast Minnesota. Topics will likely include Odonata and Lepidoptera surveys in peatlands, genetic diversity research of eastern hemlock (*Tsuga Canadensis*), Hudson Bay Eyebright (*Euphrasia hudsoniana*), and beach grass (*Ammophila breviligulata* ssp. *breviligulata*), canopy disturbance history of red and white pine, as well as several other ecological studies.

Spatial Variability of Mercury in the St Louis River Watershed across Four Landscape Types

Hope Calogero. Fond du Lac Tribal & Community College;

A Klinski; C Kowalczak; C Kowalczak; A Wold; M Castro; N Johnson, Fond du Lac Tribal & Community College & UMD

Our project was designed to complement efforts of tribal resource managers to protect natural resources vital to tribal members. Mercury contamination is a major human health concern in the St. Louis River watershed because of its harmful effects as a neurotoxin found in edible fish tissue. Fish consumption advisories suggest that humans should eat smaller and fewer fish because of these health risks. Mercury bioaccumulation impacts Indigenous Communities because fish are a large component of the

will detail lessons learned from nearly a decade of research, and briefly present trends in summer stratification, ice duration, and habitat availability for coldwater fishes.

Evidence for Mercury Contamination at the Grand Portage National Monument, MN due to Legacy Fur Trade Activity

Kristofer R. Rolfhus, River Studies Center, Department of Chemistry and Biochemistry, University of Wisconsin-La Crosse, 1725 State Street, La Crosse, WI 54601, krolfhus@uwlax.edu, 608-785-8289

Brandon R. Seitz, Grand Portage National Monument, 170 Mile Creek Road, PO Box 426, Grand Portage, MN 55605, Brandon_Seitz@nps.gov, 218-475-0123

Mercury (Hg) is a potent neurotoxin that poses exposure risks to both humans and wildlife. Our recent work found that Hg concentrations in streams and soils of the Grand Portage National Monument significantly exceeded those typically observed in the region. We detail our follow-up findings from a study of Hg in soil cores taken from historic Fort Charlotte, the Grand Portage depot, and locations between them along the Grand Portage trail. Total Hg concentrations in soil samples collected at trading forts on either end of the Grand Portage trail were 14-160 times higher than mid-trail soils, with a maximum of 15.1 ppm observed at Fort Charlotte. One possible source of historic Hg enrichment is the use, transport, and sale of trade items along the trail during the 17^{th}-18^{th} century fur trade era. Analysis of these soils for stable isotopic composition of Hg have provided a potential source fingerprint for this historic enrichment. Measures of $d^{202}Hg$ and $D^{199}Hg$ by ICP-MS indicate that the contaminated depot soils on either end of the Grand Portage trail were very similar to each other, but differed significantly from mid-trail and regional isotopic signatures. Further, contaminated soil isotope signatures from the forts matched closely with fur trade era vermilion pigment excavated locally by archeologists. Our results suggest that the Hg contamination at Grand Portage National Monument is a gradation from historic sources at the forts to contemporary sources along the trail. This work signals potentially wide-ranging implications for fur trade sites across North America.

Our project is using digital aerial imagery (ADS40) to review and assess wetland areas in lakes and islands that were omitted during the initial eFRI creation for the entire Quetico Park area. New wetland polygons will be digitized and added to the inventory during this process. The project will also investigate the use of high temporal resolution imagery (planet.com) to highlight areas of waterbodies that may appear as water in early parts of the season, but develop visible vegetation through the year.

We are also conducting a field verification of a subsample of wetland polygons delineated during our project. This field data will be used to produce an accuracy assessment of photo-interpreted ecosite call. Field verification will consist of assessing areas for ecosite, substrate, water parameters, and dominant plant species.

We will present preliminary results from both the delineation of wetlands from our imagery sources as well as our initial Fall 2018 field season.

Using Moored Temperature Arrays to Study Lakes At Isle Royale and Voyageurs National Parks

Rick Damstra, National Park Service-Great Lakes Inventory and Monitoring Network, 2800 Lake Shore Drive East Suite D, Ashland, WI 54806, richard_damstra@nps.gov, 715-682-0631

Jaime LeDuc, National Park Service-Voyageurs National Park, 360 Hwy 11 E, International Falls, MN 56649, jaime_leduc@nps.gov, 218-283-6686

Alex Egan, National Park Service-Great Lakes Inventory and Monitoring Network, 2800 Lake Shore Drive East Suite D, Ashland, WI 54806, alex_egan@nps.gov, 715-682-0631

David VanderMeulen, National Park Service-Great Lakes Inventory and Monitoring Network, 2800 Lake Shore Drive East Suite D, Ashland, WI 54806, david_vandermeulen@nps.gov, 715-682-0631

Moored temperature arrays are a relatively inexpensive method for collecting continuous water temperature data profiles in remote lakes. Consequently, we have been deploying moored temperature arrays at Isle Royale and Voyageurs National Parks since 2010 and 2011, respectively. The data we have collected are applicable to studies of limnological processes such as strength and duration of summer thermal stratification, mixing events, and ice duration These processes have a strong influence on aquatic biota, phytoplankton blooms, and habitat available to coldwater fish species, such as lake trout (*Salvelinus namaycush*) and cisco (*Coregonus artedi*). In this presentation, we

traditional diet of the population. The purpose of our project is to determine the drivers of spatial variability in mercury concentrations of the St. Louis River watershed by evaluating four types of landscapes: ditched/peatland, forested, wetland, and reservoir systems. We are examining this variability by quantifying mercury in odonates, stream water, and leaf litter. Odonates, a common food source for fish, were chosen due to site fidelity, ubiquity across the landscapes, as well as as well as ease of sampling. We chose three sample sites within each landscape type, giving a total number of fourteen sites. Total mercury (THg) and Methyl Mercury (MeHg) was measured for all samples. Dissolved organic carbon (DOC), dissolved oxygen (DO), and sulfate were also tested in the water samples. THg & MeHg was also measured in the odonate samples. Preliminary results suggest that Hg in water corresponds to Hg in odonates and that Hg in odonate tissue is higher in the streams of forested landscapes. We use this information to gain a better understanding of mercury in our water and biota.

Summary of Mist-Netting Surveys for Bats on the Superior National Forest 2013-2017

Catton. Tim. USDA Forest Service, Superior National Forest, 8901 Grand Ave Pl, Duluth, MN 55808. tcatton@fs.fed.us 218-626-4376; Kari Kirschbaum. Chippewa National Forest, Cass Lake, MN 56633;

Morgan Swingen. Natural Resources Research Institute (NRRI), University of Minnesota-Duluth, Duluth, MN 55811

In response to the expansion of white-nose syndrome across the eastern United States, the Superior National Forest began mist-netting surveys for bats in 2013 to gather baseline information on local bat populations and to augment the Forest's existing bat mobile acoustic survey transects. After a successful pilot year, the program was expanded in 2014 to include training of and with Minnesota Dept. of Natural Resources personnel and bat experts. In 2015 the Superior NF partnered with MNDNR and the Natural Resources Research Institute at the University of Minnesota-Duluth to conduct a state-wide research project entitled "Endangered bats, white-nose syndrome and forest habitat" designed to investigate roost site characteristics and summer habitat use by the northern long-eared bat (*Myotis septentrionalis*) (MYSE), which had recently been listed as Threatened under the Endangered Species Act. As a part of this project, mist-netting surveys continued to be conducted across the Superior NF during the summers of 2015-2017. Transmitters were attached primarily to reproductive female MYSE, roost sites were located using radio telemetry, emergence surveys were conducted when and where

possible, and roost tree measurements and surrounding habitat characteristics were recorded. Acoustic surveys were conducted at mist-netting sites. We present a summary of the data collected during the 5 years of these surveys.

NRRI Impacts of Emerald Ash Borer on Bird Communities

Alexis Grinde, Natural Resources Research Institute, University of Minnesota Duluth, 5013 Miller Trunk Hwy, Duluth, MN 55811, agrinde@d.umn.edu.

Melissa B. Youngquist, University of Minnesota, USDA Northern Research Station 1831 Hwy 169 E, Grand Rapids MN 55744, myoungqu@umn.edu

Josh Bednar, Natural Resources Research Institute, University of Minnesota Duluth, 5013 Miller Trunk Hwy, Duluth, MN 55811, bedn0050@d.umn.edu.

Alexis Liljenquist, Natural Resources Research Institute, University of Minnesota Duluth, 5013 Miller Trunk Hwy, Duluth, MN 55811, lilje053@d.umn.edu, 218-788-2782.

Black ash (*Fraxinus nigra*) wetlands cover extensive areas of the Great Lakes Region and the emerald ash borer (*Agrilus planipennis*; EAB) is having major effects on many native populations of ash throughout the Great Lakes Region. We are concluding a three-year investigation on the potential effects of EAB which has recently been detected in Minnesota. This project examined the impacts of EAB and adaptive management on bird diversity in Minnesota's black ash forests. Results of 29 paired upland forest and black ash stands showed that species richness and diversity was significantly higher in black ash stands and results of joint species models showed bird community composition was significantly different between the two forest types. Species commonly found in mature forests (i.e. Winter Wren, Brown Creeper) along with species that respond favorably to water (i.e. Northern Parula, Northern Waterthrush) were drivers of the differences. To assess future impacts of EAB on bird communities we also conducted point count surveys at eight experimental plots located in Chippewa National Forest, each plot had four treatments: control, simulated EAB by girdling, group selection cut (adaptive management), and clearcut (future condition). The removal of ash trees from forest stands shifted the plant communities to emergent wetland, similarly bird communities in the clearcut sites were wetland associated species (i.e. Alder Flycatcher, Song Sparrow). Bird communities did not differ significantly between control and group selection stands, this indicates group selection with under plantings is a viable forest management strategy that will maintain the unique forest bird communities found in black ash forests.

distribution and range information (i.e., county records) of common plant species. I will highlight some preliminary Sites of Biodiversity Significance and the rationale behind their designation. I will also highlight some rare plant findings and how a cross-border partnership can enhance our ability to locate new populations. Sharing knowledge of the different habitat affinities for species will benefit future surveys on both sides of the border. Finally, I will introduce our newly-developed Ecological Monitoring Network of plots that track vegetation changes due to land management, climate, and disturbance. These plots are distributed throughout the state but to reliably resample them and expand the network requires developing external partnerships

A Review, Enhancement, and Accuracy Assessment of Wetland Inventory Features in Quetico Park

Keith Hautala, Confederation College, 1450 Nakina Drive, Thunder Bay, ON, P7C 4W1, Keith.Hautala@confederationcollege.ca, 807-475-6164

Dave Thomson, Thomson Environmental, 114 Pennock Drive, Rosslyn, ON, P7K 0E1 thomson@tbaytel.net

Allan G. Harris, Northern Bioscience, 363 Van Horne Street, Thunder Bay, ON, P7A 3G3, aharris@northernbioscience.com

Sebastian Blemar-Lucero, 168 Fanshaw Street, Thunder Bay, ON, P7C 5V2, sebabelmar@gmail.com

Alain Richard, Ducks Unlimited Canada, 17504 – 111 Avenue, Edmonton, AB, T5S 0A2, a_richard@ducks.ca

Ashley Thomson, Lakehead University, 955 Oliver Road, Thunder Bay, ON, P7B 5E1, athomson@lakeheadu.ca

Accurate wetland inventories and an enhanced understanding of wetland habitat supply is increasingly important in meeting the growing requirements of fish and wildlife management, the Species at Risk and Migratory Birds Acts, and forest certification standards.

The Ontario Enhanced Forest Resource Inventory (eFRI) system includes 35 wetland ecosites, but this inventory process omits most wetlands lying within the boundary of waterbodies as well as small islands. For example, despite these wetland ecosites certainly existing in the field, the Quetico Park inventory has little area identified as shore fens and no area in organic shallow or open water marshes.

Round 4: Methods

Presentations in this section showcase methods used to suggest ways that land managers and local stakeholders could work together on cross-border projects to promote the economic, cultural and natural health of the lakes, forests and communities on the Ontario/Minnesota border.

Facilitator: Jesse Engebretson, University of Minnesota

Round 4: Abstracts

Status of Minnesota's Baseline Biological Surveys in the Border Lakes, Littlefork Vermilion Uplands, and Agassiz Lowlands Ecological Subsections

Jeffrey G. Lee, Plant Ecologist. Minnesota Biological Survey, MN Department of Natural Resources. 4805 Rice Lake Road, Duluth, MN 55803-1229. jeffrey.lee@state.mn.us. (218) 723-4763 ext. 227.

The Minnesota Biological Survey systematically collects, interprets, and delivers baseline data on the distribution and ecology of rare plants, rare animals, native plant communities, and functional landscapes needed to guide decision making. The program began in 1987 and is nearing completion of the baseline survey of the state. We completed field surveys in the last remaining county, Koochiching County, in 2018. We are currently summarizing our findings in counties within the Heart of the Continent geographic boundary (St. Louis, Lake, and Cook) and in two other counties along the Minnesota-Ontario border (Koochiching and Lake of the Woods).

By 2021, we will have finalized data that show: 1) "High" and "Outstanding" Sites of Biodiversity Significance with accompanying maps of native plant communities; 2) variations within and among native plant communities; 3) location, distribution, and viability of rare plants and animals; and 4)

Restoration Approaches in *Vaccinium*-Dominated Landscapes

Dave Grosshuesch, Tofte Ranger District, Superior National Forest, 7355 W Highway 61, Tofte, MN, 55615, dgrosshuesch@fs.fed.us, 218-663-8076

Aurelia DeNasha, LaCroix Ranger District, Superior National Forest, 320 N. Highway 53, Cook, MN 55723, aedenasha@fs.fed.us, 218-666-0055

Sarah Malick-Wahls, Kawishiwi Ranger District, Superior National Forest, 1393 Highway 169, Ely, MN 55731, smalickwahls@fs.fed.us, 218-365-2091

Tara Anderson, LaCroix Ranger District, Superior National Forest, 320 N. Highway 53, Cook, MN 55723, taanderson@fs.fed.us, 218-666-0023

Both the oak-blueberry (*Quercus spp.; Vaccinium* spp.) and dwarf bilberry (*V. caespitosum*) habitat types, already rare within Minnesota, have diminished greatly over the last 100 years due mostly to fire suppression efforts. Without some regular frequency of fire, shade-tolerant species such as balsam fir create a dense understory, thereby reducing light and nutrients for *Quercus* and *Vaccinium* spp. Under these conditions *Quercus* and *Vaccinium* spp. produce less mast or can be significantly reduced from these habitats. Both habitats are typically found on dry, nutrient poor soils, which often occur over bedrock or in well-drained soils. Mast produced from berries and acorns on oak-blueberry habitats are important food for a wide range of species. Dwarf bilberry is the exclusive host plant that northern blue butterfly (*Lycaeides idas nabokovi*) larvae feed on (both of which are Regional Forester Sensitive Species on the SNF).

Using various techniques such as brush/fir removal and prescribed burning, we attempt to restore, maintain or enhance *Quercus* spp. mast production and *Vaccinium* spp. abundance and distribution. However, there are a number of questions about the most suitable conditions to burn under, frequency of burning, and time of year to burn that remain unknown. Therefore, we initiated monitoring protocols to measure metrics, such as mast production, frequency, and invasive species, to determine effects from various treatments. We report preliminary results from dwarf bilberry units and the treatments' effects on bilberry and non-native hawkweed abundance with suggestions for management to reduce competition from non-natives at these sites.

Highlights of the 2017 Quetico Provincial Park Angling Survey

Brian W. Jackson, Biologist, Quetico Provincial Park , 108 Saturn Avenue, Atikokan, ON Ontario POT 1C0 brian.w.jackson@ontario.ca
Phone: (807) 597-5022

Angling is an important part of the Quetico Park Backcountry experience for many visitors. To help provide a better understanding of fishing activity in the Quetico, a web-based angling survey of backcountry visitors to the Quetico was conducted in 2017. A review of angler survey data from six lakes from the 1950s to 2017 shows a general increase in fishing success and a shift in focus from walleye to smallmouth bass. The survey provided information useful to support management and planning decisions for the *Fisheries Management and Aquatic Ecosystem Stewardship Plan for Quetico Provincial Park/Weh-weh-nih Gih nah wen dah meeng Aki mih nah wah Nibi.*

Red & White Pine Ecosite Relationship with Implications for Long Term Persistence in Absence of Fire in Quetico Provincial Park

Brian W. Jackson, Biologist, Quetico Provincial Park , 108 Saturn Avenue, Atikokan, ON Ontario POT 1C0 brian.w.jackson@ontario.ca
Phone: (807) 597-5022

Among the most iconic forests within Quetico Provincial Park are the stands of tall, majestic red and white pine. Natural regeneration of red and white pine tends to occur on sites with shallow soils, reduced nutrient and moisture content, and frequent fire disturbance regimes, particularly low intensity surface fires. The more sites vary from these conditions, the less likely they will be able to maintain red and white pine composition. Concern exists that reduced fire disturbance over the past century has impacted the persistence of Quetico's red and white pine dominated stands.

Adaptation Forestry practices for Climate Change Mitigation: A Field Study

Julie R. Etterson, Department of Biology, University of Minnesota Duluth, Duluth, MN, USA; email: jetterso@d.umn.edu; phone: (218) 726-8110

Meredith W. Cornett, The Nature Conservancy in Minnesota - North Dakota - South Dakota, Duluth, MN, USA; email: mcornett@tnc.org; phone: (218) 727-6119

Mark A. White, The Nature Conservancy in Minnesota - North Dakota - South Dakota, Duluth, MN, USA; email: mark_white@tnc.org; phone: (218) 727-6119

Boreal forests are experiencing some of the most dramatic changes in community composition under climate change. Over the last century, northern forests have warmed between 1-1.9°C, leading to canopy tree mortality and regeneration failures. In Minnesota USA, we tested assisted migration as a means to assess adaptation lags and a transition strategy for boreal forests. We obtained seedlings using two temperate oak species: bur oak (*Quercus macrocarpa*) and northern red oak (*Quercus rubra*), that were sourced from two seed zones (ecotypes) and planted them at 16 sites in working boreal forests. Our hypotheses were threefold: 1) tree species with more southern geographic distributions would thrive in northern forests where climate has already warmed substantially, 2) southern ecotypes of these species would have higher survival and growth than the northern ecotype in northern environments, and 3) tree fitness would be linked to traits that confer temperature and drought tolerance. We measured survival, growth, specific leaf area (SLA) and phenology from three years. For both species, survival was high overall (>93%), and southern ecotypes expressed traits consistent with our climate adaptation hypotheses. These results suggest that trees are already experiencing an adaptation lag and that assisted migration appears to be an effective a management tool in working forest settings. Future use of forestry-assisted migration will require species-specific seed transfer guidelines that account for prevailing climate trends while also considering the precise geographic origin of seed sources, rather than a static seed zone.

Influence of Eastern Spruce Dwarf Mistletoe on Structure and Composition of Black Spruce Forests in Northern Minnesota

Marcella A. Windmuller-Campione, Department of Forest Resources, 1530 Cleveland Ave. N., St. Paul, MN 55108; mwind@umn.edu 612-624-3699

Raychel Skay, Department of Forest Resources, 1530 Cleveland Ave. N., St. Paul, MN 55108; skay0001@umn.edu 612-624-3400

Matthew B. Russell, Department of Forest Resources, 1530 Cleveland Ave. N., St. Paul, MN 55108; russellm@umn.edu 612-624-3400

Black spruce (Picea mariana) is an important economic and ecological tree species in the northern boreal forest. It is one of the few tree species that can not only survive but thrive in lowland forests and is generally harvested under frozen conditions for pulpwood. The main disease of black spruce is eastern spruce dwarf mistletoe (ESDM) (Arceuthobium pusillum). ESDM is a native disease that can cause large mortality pockets and can pass from the overstory to the understory impacting regeneration. Management of ESDM often focuses on sanitation harvests or clearcuts. However, if infected residuals remain in the stand there is a chance new seedlings will face high mortality rates. There has been limited work to quantify how ESDM influences stand dynamics and stand development. This study sampled black spruce stands across a gradient of ESDM levels in northern Minnesota to explore the influence of ESDM on stand structure and composition. With higher levels of ESDM there was a shift in both overstory and understory structure and composition. Stands with higher levels of ESDM had greater amounts of balsam fir and lower levels of black spruce in both the overstory and understory. This shift in species composition and stand structure is important to quantify to allow natural resource managers to assess trade-offs related to managing both ESDM and black spruce forests types.

Technologies and Management Practices to Reduce Impacts of Light Pollution on Environmental and Human Health

Cynthia Lapp, Starry Skies Lake Superior IDA, 4218 Enterprise Circle, Duluth, MN 55811 cylapp@yahoo.com 218-343-2593

Randy Larson, Starry Skies Lake Superior IDA, 4218 Enterprise Circle, Duluth, MN 55811 randy@meteek.com 218-343-7332

Since the advent of human-produced artificial light at night, humans have utilized progressively brighter lighting, to the detriment of ecological and human health. With the advent of LED lighting technology, we can produce brighter light at more harmful color temperatures with exponentially larger habitat impact. We also have the opportunity to use existing technologies to control and minimize excess light to lower-than historic light pollution levels. Minimizing light pollution using new technologies requires alternative management practices and an understanding of lighting technologies and their impacts that goes beyond current industry standards. This is crucial in order to sustain and protect the environmental quality of the HOCP, and to support the application of multiple units within the HOCP towards Dark Sky status.

Lead Pollution from Prehistoric Copper Mining on Southwest Side of Isle Royale.

Collin Murphy, Department of Earth and Environmental Sciences and Large Lakes Observatory, University of Minnesota Duluth, 1114 Kirby Drive Heller Hall 229 Duluth, MN 55812, murph718@d.umn.edu, 218-726-7716

Byron Steinman, Department of Earth and Environmental Sciences and Large Lakes Observatory, University of Minnesota Duluth, 2205 E 5th St Duluth, MN 55812, bsteinma@d.umn.edu, 218-726-7435

Kathryn Schreiner, Large Lakes Observatory and the Department of Chemistry & Biochemistry, University of Minnesota Duluth, 2205 E 5th St Duluth MN 55812, kschrein@d.umn.edu, 218-726-8680

The Keweenaw Peninsula and Isle Royale (Michigan, United States) is host to the world's largest native copper deposit. During the second half of the 19th century, archaeologists uncovered thousands of primitive mining pits throughout the region. This mining activity marks some of the earliest known metallurgy by humans. The history of ancient copper mining in the Keweenaw peninsula and Isle Royale could have a profound impact on our understanding of the society and culture of prehistoric indigenous people of the region. It

could also be a significant milestone in the technological evolution of humanity. Notwithstanding its importance, temporal and spatial patterns for prehistoric mining are still little understood. In order to address this gap in knowledge, in 2016 several lake sediment cores were recovered to reconstruct ancient mining on Isle Royale. Lacustrine sediment recovered from a small pond on the southwest side of the island (adjacent to Siskiwit Bay) was examined for anthropogenic lead mining pollution. Weakly sorbed trace metals were extracted from sediment and concentrations were quantified via Inductively Coupled Plasma-Mass Spectrometry

(ICP-MS). Enrichment factors calculations were used to normalize lead concentrations to show the anthropogenic mining pollution signature. There were several spikes in lead concentration. These spikes indicate that prehistoric mining pollution was delivered to the pond and confirms that prehistoric mining did occur in the vicinity of the lake. Initial radiocarbon data suggests the largest concentration spike was approximately 5000 14C years before present (yr BP).

Minnesota Department of Natural Resources and the Watershed Restoration and Protection Strategies and One Watershed, One Plan Programs

Taylor Nelson, Support Hydrologist, Minnesota Department of Natural Resources,1568 Highway 2, Two Harbors, MN 55616, taylor.nelson@state.mn.us, 218-834-1442

Watershed Restoration and Protection Strategies (WRAPS) is the Minnesota Pollution Control Agency's (MPCA) approach to monitoring, assessing, and restoring impaired waters and protection unimpaired waters. MPCA and its partner organizations, including the Minnesota Department of Natural Resources (DNR), conduct intensive water quality monitoring and assessments within each of the 80 major watersheds in Minnesota on a ten year cycle. WRAPS is funded by the Minnesota Clean Water Legacy Act.

One Watershed, One Plan (1W1P) legislation permits the Minnesota Board of Water and Soil Resources (BWSR) to align local water planning and implementation with state strategies over a ten year transition period. The planning areas are built largely around the state's major watersheds and can allow comprehensive plans, local water management plans, or watershed management plans to serve as substitutes for one another, or to be replaced with one comprehensive watershed management plan.

Within the Heart of the Continent Area, multiple WRAPS have been completed or are currently in progress and the Lake Superior North 1W1P was completed.

Reconstructing Historical Forest Composition and Abundance by Using Archived Landsat and National Forest Inventory Data

Thapa, B., Department of Natural Resource Ecology & Management, Iowa State University, Ames, IA 50011, USA

Wolter, P., Department of Natural Resource Ecology & Management, Iowa State University, Ames, IA 50011, USA

Sturtevant, B..Institute for Applied Ecosystem Studies, Northern Research Station, USDA Forest Service, Rhinelander, WI 54501, USA

Townsend, P., Department of Forest and Wildlife Ecology, University of Wisconsin—Madison, 1630 Linden Drive (Suite 226), Madison, WI 53706, USA

Effective modeling of forest susceptibility to insect outbreaks requires the better understanding of outbreak dynamics and forest feedback mechanisms. It is possible with spatially explicit host and non-host species composition and abundance maps, including prior to and after the outbreak. In this paper, we combine archived Landsat sensor data with different vintages of the U.S. Forest Service's Forest Inventory and Analysis (FIA) data (periodic [1970s, 1990s] and annual [2003-2006]) to explore the utility of these ground data for modeling and mapping historic forest composition in the Border Lakes Ecoregion (BLE). Model calibration results between Landsat reflectance and FIA ground data for both forest basal area and relative basal area of balsam fir (Abies balsamea)- preferred host of most relevant forest insect pest - spruce budworm (SBW, Choristoneura fumiferana) in the region, were poor to moderate (Adj. R2 0.39 and 0.48, respectively). Results for relative basal area of aspen (Populous tremuloides) and spruce (Picea glauca and P. mariana) yielded substantially better accuracies (Adj. R2 0.64 and 0.78; RMSE 15.56 and 10.65 m2ha-1, respectively). In addition, grouping of tree species into hardwoods (HWD) and conifers (CON) substantially improved the model calibration result (Adj. R2 range: 0.72 – 0.91) with an exception to SBW host species. While satellite to ground calibration accuracies were not stellar, we determined that periodic FIA ground data from the early 1990s generated stronger model results compare to other FIA-Landsat date combinations tested. We posit four potential factors that may have contributed to less than optimal calibration results: 1) variation in FIA sampling protocols through time, 2) variability in species abundance among FIA sampling across multiple Landsat

consistent breakdown in cycle synchrony for both species in those parts of the landscape where host trees were sparse. Spruce budworm tended to cycle synchronously where forest tent caterpillar did not, and vice versa. Taken together, this suggests that forest landscape structure modulates cycle amplitude and synchrony, regardless of the forest-insect system. Our research inspired development of a hybrid insect population model that blended prevailing paradigms in insect population dynamics, where spatiotemporal patterns of outbreaks emerge from multiple drivers (natural enemies, host concentration, climatic gradients, and weather perturbations). Model results replicated the relationship between host concentration and outbreak synchrony, but also highlighted persistent spatial motion in outbreak patterns that often overwhelmed underlying relationships between host abundance and insect populations. Reanalysis of the tree-ring data revealed analogous patterns within both insect systems. Specifically, severe outbreaks tend to be followed by less severe outbreaks in both time and space. The unique juxtaposition of divergent land management legacies within the Heart of the Continent has provided a critical testing ground advancing understanding of how human-induced changes in forest landscape structure affects insect outbreak dynamics, and the state of the art in insect disturbance modelling.

Sensitivity Analysis of Canopy Fuel Loads on Crown Fire Behavior in Northeast Minnesota

Jacob Olbrich and Peter T. Wolter, Natural Resource Ecology & Management Department, Iowa State University, 132 Science-II Hall, 2310 Pammel Dr, Ames, IA 50011, jolbrich@iastate.edu, 515-294-6825, ptwolter@iastate.edu, 515-294-7312

Patricia Johnson, USDA Forest Service, Gunflint Ranger District, 2020 W. Highway 61, Grand Marais, MN 55604, pjjohnson@fs.fed.us, 218-387-3230

Past and current forest species composition and structure in northeastern Minnesota is tightly coupled with the size, frequency, and intensity of historic wildfires on this landscape, as evidenced by the abundance of fire-dependent forest species. Dense understories of predominantly balsam fir (*Abies balsamea* (L.) Mill.) make estimations of vegetation and fuel parameters difficult. As a result, wildfire perimeters are often underestimated in simulations. A sensitivity analysis of FARSITE fire spread model was conducted using the Redeye and Famine fires (2006) fires using six different estimates of canopy bulk density (CBD) in northeastern Minnesota at both 30m and 50m pixel resolution. Models were calibrated by CBD estimates derived by FuelCalc, LANDFIRE, and four combinations of canopy gap fraction (CGF) from the top two (7^o, 23^o) or top three angles (7^o, 23^o, 38^o) at either ground level or two meters above ground level. Model accuracy was assessed using a comparison of Lee-Sallee spatial correspondence metric. Preliminary results suggest CBD estimates from two angles at two meters (RMSE 0.07 kg ⍰ m^{-3}, BIC 37.91) predicted fire to the highest accuracy.

Mapping Forest Canopy Bulk Density in the Superior National Forest to Support Fire Behavior Modeling

Peter T. Wolter and Jacob J. Olbrich, Natural Resource Ecology & Management Department, Iowa State University, 132 Science-II Hall, 2310 Pammel Dr, Ames, IA 50011, ptwolter@iastate.edu, 515-294-7312, jolbrich@iastate.edu, 515-294-6825

Patricia Johnson, USDA Forest Service, Gunflint Ranger District, 2020 W. Highway 61, Grand Marais, MN 55604, pjjohnson@fs.fed.us, 218-387-3230

Inaccuracies among LANDFIRE fuel inputs have largely precluded automation of wildfire modeling efforts within the Superior National forest (SNF). As such, remote sensing strategies are needed to improve accuracy among key forest structural parameters needed for modeling wildfire. Most important among these is canopy bulk density (CBD); the amount of burnable biomass per cubic meter of forest canopy (kg □ m^{-3}). We use a combination of synthetic aperture radar at two frequencies (5.41 and 1.27 GHz) along with optical satellite data (Landsat, Sentinel-2, and SPOT-5) to model CBD. Fuels and canopy gap fraction data (ground level and two meters above ground [CGF_G and CGF_{2m}]) were collected from 62 field plots. Plot-wise estimates of CBD were derived via two methods: FuelCalc (CBD_{FC} [v1.5, Keane et al. 2017]) and transformations of CGF (CBD_T, Keane et al. 2005). Field estimates of CBD were used with satellite data to calibrate predictive models for mapping CBD. Among the two best CBD models, remote sensing predictors accounted for 96.1% and 93.3% of the observed variation among ground estimates of CBD_{FC} (RMSE 0.16 kg □ m^{-3}, BIC 65.85) and CBD_{T_2m} (RMSE 0.07 kg □ m^{-3}, BIC 37.91), respectively. Model calibrations using ground-level estimates of CBD_{T_G} accounted for 72.0% (RMSE 0.32 kg □ m^{-3}, BIC 72.10) of the observed variation. Ground-level estimates of CBD_{T_G} are especially coveted for fire behavior modeling in the SNF as they include a highly flammable component of latter fuels in this region (*Abies balsamea*), which is largely absent among the LANDFIRE data suite.

Round 3: Forest Health

Presentations in this section investigate the health of the forests of the Heart of the Continent Partnership region, especially in the context of changing conditions of the region.

Facilitator: Brian Sturtevant, USDA-FS

Round 3: Abstracts

Modelling Insect-Forest Interactions across Landscapes: Heart of the Continent Advances the State of the Art

Brian R. Sturtevant, USDA Forest Service, Northern Research Station, 5985 Hwy K, RHINELANDER, WI 54501. (p) 715-362-1105 (e) brian.r.sturtevant@usda.gov

Barry J. Cooke, Canadian Forest Service, Great Lakes Forestry Centre, Sault Ste. Marie, ON (e) barry.cooke@canada.ca

Louis-Etienne, Canadian Forest Service, Great Lakes Forestry Centre, Sault Ste. Marie, ON (e) robert.louisetienne@gmail.com

Brian R. Miranda USDA Forest Service, Northern Research Station, 5985 Hwy K, Rhinelander, WI (e) brian.r.miranda@usda.gov

Bina Thapa, Department of Natural Resource Ecology and Management, Iowa State University, Ames, IA (e) btha001@iastate.edu

Peter T. Wolter, Department of Natural Resource Ecology and Management, Iowa State University, Ames, IA (e) ptwolter@iastate.edu

The Heart of the Continent region contains three very distinct land management legacies (wilderness vs. American vs. Canadian forest land management) in zones large enough to detect discernable differences in outbreaks of both the spruce budworm (feeding on late-successional fir and spruce) and the forest tent caterpillar (feeding on early-successional hardwood species). Outbreak reconstructions from tree-ring analyses showed a

The Superior National Forest's Canada Lynx DNA Database

Tim Catton, Kawishiwi Ranger District, Superior National Forest, 1393 Highway 169, Ely, MN 55731, tcatton@fs.fed.us, 218-626-4376

Dan Ryan, Laurentian Ranger District, Superior National Forest, 318 Forestry Road, Aurora, MN 55705, dcryan@fs.fed.us, 218-229-8809

Dave Grosshuesch, Tofte Ranger District, Superior National Forest, 7355 W Highway 61, Tofte, MN, 55615, dgrosshuesch@fs.fed.us, 218-663-8076

Sarah Malick-Wahls, Kawishiwi Ranger District, Superior National Forest, 1393 Highway 169, Ely, MN 55731, smalickwahls@fs.fed.us, 218-365-2091

Shannon Barber-Meyer, Research Wildlife Biologist, USGS Wolf and Deer Project, 1393 Highway 169, Ely, MN 55731,sbarber-meyer@usgs.gov, 218-365-2087

In 2008, Superior National Forest (SNF) created and continues to maintain a database of genetically-confirmed Canada lynx (Lynx canadensis) to document their occurrence, persistence and reproduction in Minnesota. Field observations and DNA analysis were used to document reproduction and relatedness of Federally-threatened Canada lynx in Minnesota since 2002. Samples (typically scat or fur) were collected primarily as part of the SNF's survey and monitoring program. Lynx detections are distributed over 12 counties in Minnesota with the majority occurring in St. Louis, Lake, and Cook counties, where most survey efforts have been focused. DNA analysis has also detected 12 unique genotypes of F1 lynx-bobcat hybrids, 4 females and 8 males, in Minnesota.

We used non-invasive genetic data collected during snow-tracking surveys from 2012-2017 to generate estimates of abundance, trend, and density in selected core areas within our study area. We found no evidence for a decrease or increase in abundance during that period. We also used these snow-tracking data to examine spatial variation in lynx occupancy for winters 2014-15 through 2017-2018 and present predicted annual occupancy for the forest for those years.

These data provide evidence of reproduction and persistence of lynx and lynx individuals in northeastern Minnesota, offer a baseline from which to track population trends over time, and can be used to predict occupancy based on habitat features to inform forest management within the Heart of the Continent.

Evaluating the Impacts of Environmental Factors on the Eastern Larch Beetle in Minnesota

Sara Rybak, Fond du Lac Tribal and Community College, 26623 Farm to Market Road, Sturgeon Lake, MN 55783, rybak1102@gmail.com, (320)-279-0670

Co-Authors:

Dr. Mohammad Al-Hamdan, USRA at NASA Marshall Space and Flight Center. 320 Sparkman Drive NW, Huntsville, AL 35805, mohammad.alhamdan@nasa.gov, (256)-961-7465

Dr. Muhammad Barik, USRA at NASA Marshall Space and Flight Center, 320 Sparkman Drive NW, Huntsville, AL 35805, muhammad.barik@nasa.gov, (256)-961-7449

The Tamarack is an important component of lowland ecosystems in Minnesota. Tamarack trees are main habitat and breeding ground for eastern larch beetle. During their lifecycle they damage the phloem of a tamarack, which is a tissue layer where water and nutrients are transferred, causing the tree to die. The goal for this NASA CAARE (Center for Applied Atmospheric Research and Education) project is to look for trends that can be found when comparing environmental factors and the spread and severity of the current outbreak of the eastern larch beetle in Minnesota. The current outbreak that Minnesota is experiencing right now started in 2000. It is considered the longest continuous infestation of the eastern larch beetle that has ever occurred in North America.

Since 2000, more than 283,000 acres have been damaged or killed by the eastern larch beetle.

Although the main factors that contribute to the spread of the eastern larch beetle are drought and defoliation, it appears that these are not factors in the current outbreak. The beetle often colonizes in dead or extremely stressed trees, thus areas that have been affected by fire can potentially be prime breeding grounds for the beetle. Effects of various meteorological and environmental variables are investigated. These factors include soil moisture, soil temperature, evapotranspiration, snow water equivalent, enhanced vegetation index, air temperature, precipitation and wildfires.

Hill Annex Paleontology Project: Research into the Cretaceous Deposits of Minnesota

John Westgaard, Minnesota Discovery Center, 1005 Discovery Drive, Chisholm, MN 55719, jwestgaard@smm.org, (651) 263-7203

H.Douglas Hanks, Science Museum of Minnesota, 120 West Kellogg Boulevard, Saint Paul, MN. 55102, hanks.douglas@gmail.com, (612) 859-8445

The Hill Annex Paleontology Project is a volunteer research endeavor examining the Cretaceous deposits of Minnesota. Initial study and the body of historical research focuses on the open pit iron mining district of the Mesabi Iron Range. Within this area, open pit iron mining exposes a wide swath of Late Cretaceous age conglomerates, sandstones, and shales. These are believed to be deposited during the transgression of the Western Interior Seaway across the center of North America, and contain a variety of both marine and terrestrial fossils. The Hill Annex Paleontology Project is dually focused on efforts of public outreach and community engagement. Our aim is to increase awareness of these natural resources, promote their conservation and preservation, and utilize them to promote informal STEM learning opportunities.

Genetic Structure and Hybridization in North Shore Populations of Two Arctic Relict Plant Species: *Euphrasia hudsoniana* and *Primula mistassinica*

Katharine J. Zlonis, Department of Biology, University of Minnesota Duluth, 1035 Kirby Drive, Duluth, MN 55812; wink0113@d.umn.edu

Julie R. Etterson, Department of Biology, University of Minnesota Duluth, 1035 Kirby Drive, Duluth, MN 55812; jetterso@d.umn.edu

Briana L. Gross, Department of Biology, University of Minnesota Duluth, 1035 Kirby Drive, Duluth, MN 55812; blgross@d.umn.edu, 218-726-7722

In North America, relict arctic plant populations from the last glacial maximum persist in disjunct locations south of their normal range. These fringe populations may be particularly threatened by stressors associated with climate change, including increased temperature, decreased water availability, and increased competition with invasive species. In Minnesota, several arctic relicts of conservation concern are restricted to the rocky coast immediately adjacent Lake Superior, including *Euphrasia hudsoniana* and *Primula*

discuss the relative significance of wilderness to individual wolf survival in the context of other potentially important covariates.

The Voyageurs Wolf Project: Uncovering the Secret Lives of Wolves in the Heart of the Continent

Thomas D. Gable, University of Minnesota, 2003 Upper Buford Circle, St. Paul, MN 55801, thomasd.gable@gmail.com

Steve K. Windels, Voyageurs National Park, 360 Highway 11 E, International Falls, MN 56649, steve_windels@nps.gov

Austin T. Homkes, Voyageurs National Park, 360 Highway 11 E, International Falls, MN 56649, austin.homkes@gmail.com

Joseph K. Bump, University of Minnesota, 2003 Upper Buford Circle, St. Paul, MN 55801, bump@umn.edu

The Voyageurs Wolf Project is a collaboration between the University of Minnesota and Voyageurs National Park. The project was started in 2015 to study the ecology of wolves and their prey (moose, deer, and beavers) during the summer in the Greater Voyageurs Ecosystem. The ecology of wolves during the summer in southern boreal ecosystems, such as the Heart of the Continent, has remained elusive due to the challenges of studying wolves in densely forested habitats during summer. Given this, our goal is to provide a comprehensive understanding of the summer ecology of wolves in the Greater Voyageurs Ecosystem, which will benefit the management and conservation of wolves, their prey, and the habitat both need. We will briefly discuss our project methods, our important findings so far, and our long-term project goals. Lastly, we will discuss why we think the Voyageurs Wolf Project is a worthwhile and valuable outreach tool for not only Voyageurs National Park, but the entire Heart of the Continent.

Round 2: Predators on the Landscape

Presentations in this section are research that investigates the how predators thrive (or not) on the landscape of the Heart of the Continent Partnership region, especially in the context of changing conditions of the region.

Facilitator: Shannon Barber-Meyer, USGS

Round 2: Abstracts

The Role of Wilderness in Wolf Survival and Cause of Death over 50 years

Shannon Barber-Meyer, U. S. Geological Survey, Northern Prairie Wildlife Research Center, Wolf and Deer Project, 1393 Highway 169, Ely, MN 55731 USA, sbarber-meyer@usgs.gov, 218-365-2087
Tyler Wheeldon, Ontario Ministry of Natural Resources And Forestry, 2140 East Bank Dr, Peterborough, Ontario, K9L 1Z8, tyler.wheeldon@ontario.ca, 705-755-2279
L. David Mech, U. S. Geological Survey, Northern Prairie Wildlife Research Center, Wolf and Deer Project, The Raptor Center, University of MN, 1920 Fitch Ave., St. Paul, MN 55108 USA, mechx002@umn.edu, 651-649-5231

Wolves (*Canis lupus*) can persist in a great variety of habitats from Mexico toward the North Pole. The influence of wilderness habitat on wolf survival and cause of death remains largely unexamined. We analyzed the survival of radiocollared wolves (n=756 collared-wolf tenures) over a 50 year study (1968-2018) in the Superior National Forest, Minnesota, USA, an area that also includes the Boundary Waters Canoe Area Wilderness. The annual survival estimate was 0.83 (95% Confidence Interval = 0.77-0.89) for adult wolves captured in wilderness and 0.77 (95% Confidence Interval = 0.74-0.80) for those captured in non-wilderness. Wolves captured out of wilderness died from 38% natural (86/229), 45% human (103/229), and 17% unknown (40/229) causes compared with wolves captured in wilderness that died from 47% natural (15/32), 25% human (8/32), and 28% unknown (9/32) causes. During Nov-Apr, 1968-2011 (excluding study years during and after the legal wolf harvest) adults and pups captured in wilderness were 0.59 times (95%CI=0.35-0.98) less likely to die than wolves captured in non-wilderness (P=0.04). We

mistassinica. We have used GBS (genotyping-by-sequencing) to assess genetic structure and diversity in populations of these species along the north shore of Lake Superior, evaluating their connectivity and relatedness. We also examined whether there is evidence for hybridization between *E. hudsoniana* and its invasive congener, *E. stricta*. Population genetic analyses show differentiation among all populations on the north shore, with interesting groupings of non-adjacent populations that indicate unexpected paths of gene flow. In addition, we found limited gene flow from *E. stricta* to *E. hudsoniana*, but observed greater gene flow in the opposite direction. These genetic studies will be complemented with detailed phenotypic selection and population viability analyses over the next three years.

Presentations

Tuesday, April 9, 2019

8:30 a.m. – 4:45 p.m.

Kirby Student Center

University of Minnesota - Duluth

Time	Category	Presentation	Facilitator
8:30AM		**Registration, coffee**	
9:00		**Welcome, Plan for the Day**	**Tonia Kittelson, HOCP Co-Chair**
9:10 AM	Partnerships	Ryan Bergstrom, UMD, Timber, Taconite & Tourism	
9:25 AM	Partnerships	Randel Hanson, LSC, Agriculture and the Western Lake Superior Region's Past, Present and Future	
9:40 AM	Partnerships	Kathryn Milun, UMD, Bringing Insights On Community Trust-Owned Renewable Energies From Around the World to Our Northern Shores	
9:55 AM	Partnerships	Trent Wickman, USDA FS-SNF, Air Pollution Across the Heart – Trends, Ecosystem Effects and Emerging Threats	
10:10 AM	Partnerships	**Facilitated Discussion (15 Minutes)**	**Jesse Engebretson**
10:25		**15-Minute Break**	
10:55 AM	Predators	Shannon Barber-Meyer, USGS, The Role of Wilderness in Wolf Survival and Cause of Death over 50 years	
11:10 AM	Predators	Thomas Gable, UMN, The Voyageurs Wolf Project: Uncovering the Secret Lives of Wolves	
11:25 AM	Predators	Sarah Malick-Wahls, USDA FS-SNF, The Superior National Forest's Canada Lynx DNA Database	
11:40 AM	**Predators**	**Facilitated Discussion (15 minutes)**	**Shannon Barber-Meyer**
11:55		**45 – Minute Lunch**	
12:50 PM	Forest Health	Brian Sturtevant, USDA-FS, Modelling Insect-Forest Interactions Across Landscapes	
1:10 PM	Forest Health	Bina Thapa, ISU, Reconstructing Historical Forest Composition and Abundance by Using Archived Landsat and National Forest Inventory Data	

Air Pollution Across the Heart – Trends, Ecosystem Effects and Emerging Threats

Trent R. Wickman, USDA Forest Service, 8901 Grand Ave Place, Duluth, MN 55808, twickman@fs.fed.us, 218-626-4372

Air pollution has been a concern in this area since the 1970s, as evidenced by the commencement of monitoring activities at this time. Initial concerns focused on acid rain, later followed by mercury pollution. These stressors can cause a cascade of ecosystem effects including, acid rain decreasing fish abundance, and mercury pollution contaminating fish and fish-eaters. Monitoring done over the years to track these different chemical stressors has shown a mixed bag of trends – some have markedly decreased, others remained flat, while others are increasing. Determining how these chemicals affect the ecosystem has been ongoing and recent science is giving us new insights into these problems. What threats the future may hold is also discussed.

cold-weather climates in fragile ecosystems. To do so we need to build institutional capacity to promote collaboration among scientists, managers, and other partners across political, cultural, and administrative boundaries so that agricultural resources can be better managed in a landscape context.

Re-imagining and Managing Our Region's Solar Resources: Bringing Insights On Community Trust-Owned Renewable Energies From Around the World to Our Northern Shores

Kathryn Milun, Department of Anthropology, University of Minnesota Duluth, 1123 University Drive, Duluth, MN, kmilun@d.umn.edu . 218-726-7017

Sunshine is one of the greatest natural resources of our Lake Superior region. We are otherwise energy poor and so, in the twentieth century, we turned to coal and more recently natural gas to power our electricity generation. As knowledge of the causes and solutions to global warming take hold of the ratepayers of these northern shores, the demand for electricity made from sun, water, and wind increases.

If voters in the state of Minnesota decide to create a 100% renewable energy mandate for the state, what would this look like in our region? In particular, what kinds of local benefits might incentivize greater use of our most abundant and local energy resource, the sun? Studies have quantified the solar capacity of the Arrowhead region, but without context of local solar incentives (economic, cultural, social), these remain abstract numbers, not inducements to energy change.

This paper offers insights into the management of our region's solar capacity by reviewing case studies of local, community-owned solar and wind projects around the world and considering their adoption in the Heart of the Continent geographic area. Special attention is given to a new model of local community wind and solar ownership--community trust ownership. Of particular interest is how this model embeds solar and wind energy in local values and landscapes reimagined as equitable and ecological places to live. By comparing community solar and wind ownership in diverse communities around the world, this paper helps expand how our region approaches the management of our local solar resources.

1:25 PM	Forest Health	Marcella Windmuller-Campion, UMN, Influence of Eastern Spruce Dwarf Mistletoe on Structure and Composition of Black Spruce Forests	
1:40 PM	Forest Health	Julie Etterson, UMD, Adaptation Forestry Practices for Climate Change Mitigation: A Field Study	
2:10 PM	Forest Health	**Facilitated Discussion (15 minutes)**	**Brian Sturtevant**
2:25		**15-Minute Break**	
3:10 PM	Methods	Jeffrey Lee, MN DNR, Status of Minnesota's Baseline Biological Surveys in the Border Lakes, Littlefork Vermilion Uplands, and Agassiz Lowlands Ecological Subsections	**Jesse Engebretson**
3:25 PM	Methods	Keith Hautula Confederation College, A Review, Enhancement, and Accuracy Assessment of Wetland Inventory Features in Quetico Park	
3:40 PM	Methods	Kristofer Rolfhaus, UW-LaCrosse, Evidence for Mercury Contamination at the Grand Portage National Monument, MN due to Legacy Fur Trade Activity	
3:55 PM	Methods	Rick Damstra NPS, Using Moored Temperature Arrays to Study Lakes at Isle Royale & Voyageurs NPs	
4:10 AM	Methods	Kathryn Vall, UMD, Reconstruction of Paleoenvironmental Conditions and Temporal Patterns of Ancient Mining on Isle Royale using Biogeochemical Analyses of Lake Sediment	
4:25 PM	Methods	**Facilitated Discussion (15 minutes)**	**Jesse Engebretson**
4:40 PM	**Wrap-Up & Adjourn**		**Kittelson**

The Heart of the Continent
Ontario, Canada • Minnesota, U.S.A.

Presentation Abstracts

Round 1: Partnership

Presentations in this section combine management with science-based research and suggest ways that land managers and local stakeholders could work together on cross-border projects to promote the economic, cultural and natural health of the lakes, forests and communities on the Ontario/Minnesota border.

Facilitator: Jesse Engebretson, University of Minnesota

Round 1: Abstracts

Sustaining Minnesota's Arrowhead Region: Timber, Taconite and Tourism

Ryan D. Bergstrom. Assistant Professor, Program in Geography. University of Minnesota Duluth. 324 Cina Hall.Duluth, MN 55812. rbergstr@d.umn.edu. 218-726-6620

Afton Clarke-Sather. Program in Geography. University of Minnesota Duluth. 324 Cina Hall.Duluth, MN 55812. afton@d.umn.edu. 218-726-7875

The seven counties that make up northeastern Minnesota are known collectively as the "Arrowhead." The region is vast, covering over 27,000 square kilometers; rural, with a population of less than 250,000; and rugged, covered with thousands of glaciated lakes and dense forests. Because of the region's unique geologic history, the extraction of its natural resources, primarily iron ore and timber, has literally built the nation and reshaped the region both economically and environmentally. At the same time it has also produced a thriving recreation and tourism industry that draws tourists from across the globe.

Despite the success of these three industries, which often seem at odds with one another, the regional poverty rates can reach close to 17 percent, nearly twice the statewide average. Dependence on resource extraction has resulted in ongoing recognition that in order to achieve long-term sustainability, economic diversification is critical. Complicating this narrative is the upcoming

decision by the State of Minnesota to allow extraction of one of the largest undeveloped deposits of copper, nickel and precious metals in the world; a decision that will determine the economic and environmental fate of the region for decades to come.

As such, the objective of this study was to determine how communities throughout the northeastern Minnesota perceive, prioritize and act upon issues of sustainable community development and natural resource management, and how those perceptions and priorities differ spatially and temporally in the face of proposed copper-nickel and precious metal mining.

Agriculture and the Western Lake Superior Region's Past, Present and Future

Dr. Randel D. Hanson, Eco-Entrepreneurship Program, Lake Superior College, 2101 Trinity Road, Duluth, MN 55811,randel.hanson@lsc.edu, 218-349-2956.

This presentation explores the history, present and future agricultural activities in the Western Lake Superior region, pointing toward an emerging 'confusion of regimes' imposed by anthropogenic climate change while suggesting mitigative responses.

Current social, economic, and environmental conditions are leading to a resurgence in agricultural activities in the Western Lake Superior Region. Specifically, the predicted impacts of climate change, along with increased citizen/consumer interest in local/healthy foods and the tremendous economic development potential offered by local food production, is expected to dramatically increase the amount of active agricultural land in the Minnesota Coastal Zone in the coming decades. As this development takes place, a 'confusion of regimes' is expected to take shape in which social and climate capacities and expectations may be out of step with a soil make-up created by post glaciation boreal forest regime. These ill-fitting regimes set the stage for more general case study in the challenges and opportunities related to anthropogenic climate change as they point toward specific localized challenges.

Considering these social and ecological contradictions related to anthropogenic climate change, how do mitigate negative environmental consequences of increased agricultural production in the coastal zone by developing, improving, and demonstrating environmentally sustainable and economically viable food production methods that are specifically designed for