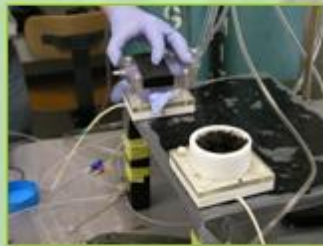




Sixth Annual
WESTERN GREAT LAKES
RESEARCH CONFERENCE

April 1-2, 2008



Northern Michigan University
Marquette, Michigan



6th Annual
Western Great Lakes Research Conference
April 1-2, 2008



The Western Great Lakes Research Conference provides a forum for information and idea sharing between researchers and managers of national parks and other public lands throughout the Western Great Lakes area.

This conference provides an opportunity for participants to share current research, monitoring, and management issues affecting parks and protected areas.

Steering committee members include: **Jerrold Belant**, NPS-Pictured Rocks Science Center; **Bruce Leustcher**, NPS-Pictured Rocks National Lakeshore; **Lora Loope**, NPS-Pictured Rocks National Lakeshore; **Joy Marburger**, NPS-Great Lakes Research and Education Center, Indiana Dunes National Lakeshore ; **Bill Route**, NPS-Great Lakes Inventory & Monitoring Network, **Jerrilyn Thompson**, NPS, Great Lakes-Northern Forest Cooperative Ecosystem Studies Unit; and **Stella Collier**, Great Lakes-Northern Forest Cooperative Ecosystem Studies Unit, University of Minnesota.

Special thanks to **Jim Northup**, NPS-Pictured Rocks National Lakeshore; and **Jill Leonard** and **Dr. Les Wong**, Northern Michigan University.

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CONFERENCE SCHEDULE

TUESDAY, APRIL 1, 2008

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	Jim Northup, National Park Service, Superintendent, Pictured Rocks National Lakeshore	
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	Brenda Moraska Lafrancois*, NPS, St. Croix Water Research Station; Ken Hyde*, NPS-Sleeping Bear Sand Dunes National Lakeshore	
9:15 – 9:30	Using Diatoms and Paleolimnology for Biomonitoring in the Western Great Lakes National Parks	34
	Mark B. Edlund*, Joy M. Ramstack, and Daniel R. Engstrom, St. Croix Watershed Research Station, Science Museum of Minnesota; Joan Elias, NPS-Great Lakes I&M Network	
9:30 – 9:45	Understanding the Past to Plan for the Future: Paleoecology of the St. Croix River	50
	Joy M. Ramstack*, Mark B. Edlund, and Daniel R. Engstrom, St. Croix Watershed Research Station, Science Museum of Minnesota; Laura D. Triplett, Gustavus Adolphus College	
9:45 – 10:00	Three Decades of Water Quality Change (1976-2005) in the Mississippi National River and Recreation Area	42
	Suzanne Magdalene*, St. Croix Watershed Research Station, Science Museum of Minnesota; Brenda Moraska Lafrancois, NPS-GLKN; D. Kent Johnson, Metropolitan Council Environmental Services	
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10:30 – 10:45	Development of a Continuous, Flow-through Test System to Chronically Expose Juvenile Unionid Mussels to Pharmaceutical Compounds	45
	Jeff Meinertz*, Theresa M. Schreier, and Michelle Bartsch, USGS, Upper Midwest Environmental Sciences Center	



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11:15 – 11:30 Mercury and Methylmercury in Small Lake Ecosystems in Voyageurs National Park, Minnesota Mark E. Brigham* and Laurel G. Woodruff, USGS; Mark B. Sandheinrich, University of Wisconsin-La Crosse	29
11:30 – 11:45 Influence of Forest Fires on Levels of Mercury in Forest Soils, Lake Superior Region Laurel G. Woodruff* and William F. Cannon, USGS	57
11:45 – 12:00 Development of a Lake Superior Basin Amphibian and Reptile Monitoring Program Gary Casper*, Great Lakes Ecological Services, LLC; Stephen Hecnar and Ashley Spencely, Lakehead University	31
12:00 – 2:00 LUNCH AND POSTER VIEWING	
2:00 – 2:15 Does Adult Body Condition Affect Recruitment Potential in Lake Whitefish (<i>Coregonus clupeaformis</i>)? Ronald E. Kinnunen*, Michigan Sea Grant-Michigan State University; Trent M. Sutton, University of Alaska Fairbanks; Marten A. Koops and John D. Fitzsimons, Great Lakes Research Laboratory for Fisheries and Aquatic Sciences; Andrew M. Muir, Purdue University; Michael T. Arts, Environment Canada-National Water Research Institute; Timothy B. Johnson, Ontario Ministry of Natural Resources; Randall M. Claramunt, Michigan Department of Natural Resources; Mark P. Ebener, Chippewa/Ottawa Resource Authority	38
2:15 – 2:30 Growth in Coaster Brook Trout: Seasonal and Hormonal Effect Carla Serfas*, Rachel Holman, Lindsey Watch, and Jill Leonard, Northern Michigan University	53



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3:30 – 3:45 Avian Response to Human Trail Use in Pictured Rocks National Lakeshore Katie L. Anderson* and John G. Bruggink, Northern Michigan University; Jerrold Belant, NPS-Pictured Rocks Science Center	28
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11:30 – 11:45 Sharing YOUR Results with Managers, Educators, and the Public; The Great Lakes Research and Education Center is Here to Help Wendy W. Smith, NPS-Great Lakes Research and Education Center, Indiana Dunes National Lakeshore	54
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POSTER PRESENTATION ABSTRACTS



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Poster Abstract

Cultural Resource Survey using GIS Modeling of Geoarchaeological Contexts in the Pictured Rocks National Lakeshore

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Archaeological survey in the Pictured Rocks National Lakeshore has been hampered by thick forest cover, lack of soil exposures, and the need for a better understanding of the park's landforms. Consequently, a Geographical Information System was developed to model the predicted location of archaeological sites in the Pictured Rocks. Subsequent Phase I cultural resource survey was then used to test the accuracy of the site location model. Twenty-three new archaeological sites were found and mapped, which has allowed further refining of the original site location model. These newly found sites indicate much more widespread use of the area during the Archaic period (800-2000 years ago) than was previously thought.



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Poster Abstract

Biodiversity Stewardship of a Preliminary Ecological Reference Area (ERA) Network on Michigan's State Forest Land

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The Michigan Department of Natural Resources (DNR) manages a 3.9 million acre state forest system using sustainable forestry principles that integrate reforestation, managing, growing, nurturing, and harvesting of trees for useful products with the conservation of soil, air and water quality, wildlife and fish habitat, visual qualities and recreational opportunities. In 2005, Michigan's state forest system achieved dual forest certification under Sustainable Forestry Initiative (SFI) Forest Stewardship Council (FSC) standards. An important criterion of forest management and certification was the implementation of an ongoing Biodiversity Conservation Planning Process and an emphasis on biodiversity stewardship of natural areas and the protection of representative samples of existing ecosystems.

In tandem, the DNR established a preliminary network of Ecological Reference Areas composed of known occurrences within the Michigan Natural Features Inventory (MNFI) database on state forest lands of high-quality natural communities that are globally (G) or state (S) critically imperiled (G1/S1), imperiled (G2/S2), or rare (G3/S3) as defined by NatureServe's natural heritage methodology. In 2006 and 2007, MNFI ecologists surveyed the 178 natural communities comprising 127,076 acres and 37 different natural community types within this preliminary ERA network. Ecologists assessed ecological integrity, and detailed the vegetative structure and composition, landscape and abiotic context, threats, management needs and restoration opportunities for each area. Information gathered from this survey effort is helping the DNR prioritize management and facilitating the selection of additional Ecological Reference Areas. The DNR is developing individual management plans for each ERA utilizing a modified format from The Nature Conservancy's (TNC) 5S Framework. The DNR is obtaining public input via the DNR State Forest Compartment Review Process. Since not all known high-quality natural communities are represented on state forest lands, cooperation among public and private partners will be necessary.



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Poster Abstract

Water Quality Monitoring in National Park Units of the Upper Great Lakes Region

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The Great Lakes Inventory and Monitoring Network (GLKN) is one of 32 National Park Service monitoring networks throughout the United States, which include over 270 national park units. The GLKN consists of 9 park units, all with important aquatic resources. The inland lake resources of GLKN parks are astounding, numbering in the thousands. Lakes larger than one hectare number in the hundreds, with nearly 300 occurring in Voyageurs National Park alone.

GLKN began monitoring water quality of inland lakes in 2005.

Our sampling design consists of annual monitoring at 33 index lakes across 6 park units, with additional lakes sampled on a longer rotation as funding permits. Within each park, the index lakes were selected to span gradients of lake type as determined by ordinations of past water quality data, geographical location within each park, visitor use, lake basin morphometry, and watershed size. Particular management interest by the parks was also a selective factor. Across the Network, the lakes span a wide range of chemical and physical characteristics, as well as ease of access for monitoring.

Sampling is conducted three times annually during the open water season. Parameters measured include the core suite (profiles of temperature, pH, conductivity, and dissolved oxygen), water clarity, water level, chlorophyll-a, dissolved organic carbon, alkalinity, major anions and cations, and nutrients. In addition, because diatoms are powerful bioindicators of environmental conditions in aquatic systems, we collected surface sediments from each lake, and will continue to do so approximately every 5 years for analysis of diatom communities.

Our water quality monitoring program follows strict quality assurance/quality control procedures including calibration acceptance criteria, sonde stabilization criteria, check of instrument bias, alternative measurement sensitivity, field and lab duplicates, and equipment blanks.

A summary of the first 3 years of sampling is presented.



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Poster Abstract

A New Method for Visualizing How Well Different Habitats Achieve Management Priorities

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Managers considering restoration of landscapes often face a fundamental challenge – what should be the habitat composition of the restored landscape?

We present a method, based on bird distributions, for examining an important conservation trade-off inherent in making that decision. To understand benefits of different potential landscape compositions, we evaluated how different proportions of five habitats – open grassland, savanna, woodland, scrub, and forest - might affect the conservation value of the Indiana Dunes landscape for birds. Two variables that resource managers typically value were examined, *Species Diversity*, a measure of avian community richness, and *Conservation Index*, the percentage of a bird species' global population occurring on a hectare of landscape, summed across all bird species present. Higher values of Conservation Index were associated with higher local densities of globally rarer and more threatened species. Conservation Index and Species Diversity were negatively correlated across hypothetical landscapes composed of different proportions of the five habitats. Therefore, a management trade-off existed between Conservation Index and Species Diversity because landscapes that maximized Species Diversity differed from landscapes that maximized Conservation Index. A landscape of 50% open, 22% savanna, 15% scrub, and 13% forest was predicted to represent a compromise at which Conservation Index and Species Diversity reached the same percentage of their maxima. In contrast, non-wetland, terrestrial habitats at Indiana Dunes National Lakeshore are currently dominated by forest.

Quantification of Conservation Index and Species Diversity allowed us to evaluate the ability of different landscape compositions to achieve preferable trade-off compromises, such as maximizing diversity for a given level of landscape use by threatened species. Managers can use these trade-off results to determine which landscape compositions are associated with particular conservation and management priorities.



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Poster Abstract

Status of the Threatened Pitcher's Thistle in the Grand Sable Dunes at Pictured Rocks National Lakeshore

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Pitcher's thistle, an endemic to the Great Lakes, is listed as a threatened species by the U.S. Fish and Wildlife Service (USFWS). It is an early successional species that has adapted to survive the stresses of the dynamic physical environment of beaches and dunes. The only U.S. population of Pitcher's thistle in the Lake Superior basin is located in the Grand Sable Dunes at Pictured Rocks National Lakeshore (PIRO).

In 2002, the USFWS approved a Pitcher's Thistle Recovery Plan, which requires development of management plans, long-term monitoring, population and age class estimations, mapping, and study of threats to assist the goal of delisting Pitcher's thistle. I propose to fulfill these requirements by assessing Pitcher's thistle within the Grand Sable Dunes at PIRO.

I will use a multivariate approach to determine what biotic and physiographic variables are predictors of Pitcher's thistle abundance on a broad (dune-wide) scale and fine (local) scale.

The broad scale approach will consist of dividing the entire dunes into 80x80-m grid cells and surveying each cell for Pitcher's thistle and associated variables. The fine scale approach will use smaller, stratified random 5-m radius plots that will include more detailed measurements of Pitcher's thistle abundance, age class structure, and associated variables.

The outcomes of this research will help determine the distributional patterns, population size and demography, associated ecological communities and conservation aspects of Pitcher's thistle in the Grand Sable Dunes. Plus, a detailed Pitcher's thistle management plan will be developed which will guide Pitcher's thistle and dune dynamics monitoring, invasive exotic plant control, and visitor use of the Grand Sable Dunes in PIRO.



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Poster Abstract

Diet Analyses of Shorebird Species Affected by a Botulism Outbreak in Sleeping Bear Dunes National Lakeshore, MI

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A recent Type E botulism outbreak in northern Lake Michigan, at Sleeping Bear Dunes National Lakeshore, devastated the aquatic avian community. Shorebirds of varying species experienced a large die-off during summer 2007. Because of this, it is necessary to determine the dietary vector causing the spread of the bacteria and whether there is a link between invasive zebra mussels or round goby and the outbreak.

In this project, specimens were collected by the National Park Service and shipped to Northern Michigan University where the birds were dissected and gut analyses were performed.

Fifteen species (58 individuals) were examined including common loon, double crested cormorant, long tail duck, bufflehead, gulls, grebes, scoters, and mergansers. Gut contents were stored in ethanol until further sorting and ID determinations were made. 19% of the birds contained identifiable fish bones, and in at least one case musculature. 15.5% of birds had clear evidence of dreissenid mussels (likely zebra mussels) and these samples were distinguishable from gastropod mollusks also seen in the collection. Other taxa found in the samples included crayfish, insects, passerine birds, and small mammals.

These data support the involvement of fish and invasive mussels in shorebird die-offs; however, they point out that other forage taxa may also be critical in this system.



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Poster Abstract

The HACCP Approach to Prevent the Spread of Aquatic Invasive Species by Natural Resource Management and Research Activities

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The potential exists for aquatic invasive species (AIS) to spread to uninfested waters through research, management, consulting, and enforcement activities. These activities are diverse and complex, as are their risks of spreading AIS. Some of these activities pose no or very low risk of spreading AIS. To deal effectively with this potential vector, it is important to characterize field activities according to their risks of spreading AIS. Without adequate risk assessment of individual field activities the risk of spreading AIS is possible.

One approach to this problem is to apply the Hazard Analysis and Critical Control Point (HACCP) concept similar to that used by the seafood industry to minimize seafood consumption health risks. The advantages of this system are that it can effectively deal with diverse natural resource management and research activities and when properly applied is effective. The HACCP approach concentrates on the points in the process that are critical to the safety of the field activity, minimizes risks, and stresses communication amongst those involved with natural resource management and research activities and helps prevent the further spread of AIS.



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Poster Abstract

**Distinguishing Native (*Celastrus scandens*) and Invasive (*C. orbiculatus*)
Bittersweet Species Using Morphological Characteristics**

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Celastrus orbiculatus is an invasive liana in the eastern United States. Its native congener, *C. scandens*, is less common and declining in the Northeast. The correct identification of these two species is often difficult because of their similar vegetative characteristics. Using morphological characteristics of both species growing naturally along a sand dune/forest ecotone at Indiana Dunes National Lakeshore, we built models for use in discriminating between the species, given a suite of leaf and fruit traits.

We tested these models using leaves and fruit collected at Indiana Dunes National Lakeshore, and leaves from Warren Dunes State Park in Michigan, and Illinois Beach State Park and Lyons Woods in Illinois.

We confirmed that the two species can be discriminated effectively using fruit characters, notably fruit volume and seed number. Several leaf traits, such as length-to-width ratio and leaf apex length can also discriminate between the species, but without the same predictive reliability of fruit traits. In addition, we determined that at leaf out in the spring the leaves of the two species were folded differently in the bud allowing them to be successfully discriminated without fruit or flowers present. Land managers could use this information to differentiate between the two species in the field and thereby control for the *invasive* *C. orbiculatus*, while preserving remaining populations of *C. scandens*.



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Poster Abstract

Explanation of the Buried Forest of Little Traverse Bay, Houghton County, MI

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Two samples were taken from a section of submerged tree stumps along the Lake Superior shoreline on Little Traverse Bay. The stumps in this area appear to be in growth positions, partially buried in the sand and submerged in shallow water. Wave and ice action in the shallow water causes erosion to be significant, and most stumps are truncated at the water level.

Through this study we would like to answer several questions: how old are the trees, and how did they come to be buried in the beach? If the stumps are in fact recent (less than 100 years), can their burial be explained by human influences or natural events? If the tree stumps are older, then what environment did they live in and what type of events could have buried the forest could it have been due to glacial action or changes in sedimentation? In the event that the tree species can be identified, we can determine the likely growth environment, as well as infer the probable distance from the paleo-shoreline.

Samples from the stumps will be sent to a laboratory for radiometric dating. While we wait for the results of the testing, we will focus on the other aspects of the site from which these stumps were taken. The first of these aspects will be to examine the growth environment and determine possible mechanisms that would result in trees being buried in the beach and eventually submerged by the waters of Lake Superior. Through studying the history of the area, we can hopefully explain this phenomenon regardless of the age of the trees. Identification of the tree species would allow us to draw conclusions about what the environment was like for these trees when they were alive, as well as make possible conclusions about the climate before they became buried on the shore. Taking all this data into account, we should be able to unravel a bit of the history of the Little Traverse Bay area. Whether the trees turn out to be young or old, their position needs explaining; the age will simply allow us to determine what the most likely causes were. What factors led to the burial of these trees and what was the paleoenvironment at the time of their existence these are the questions we hope to answer with this study.



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Poster Abstract

The Great Lakes Research and Education Center - Linking Research and Education in the Great Lakes National Parks (2003-2007)

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Since 2003 the Great Lakes Research and Education Center (GLREC) has coordinated two multi-park research projects in the Great Lakes region and several research projects at Indiana Dunes National Lakeshore (INDU), as well as assisting with an international research project. In addition, 50 research and collection permits for INDU were managed by the center in 2007.

Research and education is facilitated through various organizations including the USGS, Michigan Technological University, Purdue University, University of Illinois, Loyola University at Chicago, Sea Grant, and the Chicago Field Museum. The center also coordinates programs with other Research Learning Centers, the Great Lakes-Northern Forest Cooperative Ecosystem Study Unit, the Great Lakes Inventory and Monitoring Program, and the Exotic Plant Management Team. The GLREC has developed several research-related outreach products, including workshops and publications. In 2005 the GLREC developed an ongoing summer research internship program to provide managers with research assistance and a learning experience for students.

The center is meeting its Natural Resource Challenge goals of facilitating research and research-related science education in the network parks.



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Poster Abstract

Effect of Removal of *Hesperis matronalis* (Dame's Rocket) on Forest Understory Vegetation in NW Indiana

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Exotic invasive plants differ in their effects on indigenous vegetation as evidenced by research evaluating community response to their removal. We used this removal approach to quantify the response of a mesic woodland to the removal versus retention of an invasive plant, dame's rocket (*Hesperis matronalis*) from paired treatment plots over three years.

Dame's rocket is an invasive plant of mesic woods and floodplain forests and is common in the central Midwest.

This work was conducted in a disturbed mesic forest on the Glenwood Dunes at Indiana Dunes National Lakeshore. Cover of dame's rocket did not differ between control and treatment plots prior to removal, declined in the removal plots and remained significantly lower in cover compared to the control plots. Removal did not significantly affect species richness and species diversity (evenness, Shannon, and Simpson) at the plot scale but did result in increased species richness overall in the treatment plots in the summer of the last sampling year, when compared to control plots.

Ordination analysis indicated a significant compositional change in the spring plant composition of plots over the three years, reflecting an increase in exotic woody species. Exotic woody plants, especially *Rosa multiflora* and *Euonymus alatus*, increased in cover in response to *H. matronalis* removal.

In the three years, neither native nor exotic forbs, nor native woody plants responded to the removal of *H. matronalis* in a statistically significant manner. The apparent response of woody invasive plants from the removal of dame's rocket has important implications for restoration of degraded communities.



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Poster Abstract

Spatial Patterns and Levels of Persistent Contaminants in Nestling Bald Eagles at Three National Parks in the Upper Midwest

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In 2006 and 2007 bald eagle nestlings were sampled to monitor persistent, bioaccumulative toxics (PBTs) at the Apostle Islands National Lakeshore, the St. Croix National Scenic Riverway, and the Mississippi National River and Recreation Area. Blood and feather samples were taken from 50 nestlings in 32 nesting territories in 2006 and from 54 nestlings in 38 territories in 2007. Samples from one nestling per nest were sent to the Wisconsin State Laboratory of Hygiene (WSLH) to determine concentrations of targeted contaminants. We sampled for two legacy contaminants - PCBs and DDT (including metabolites DDE and DDD); two heavy metals - mercury and lead; and three emerging contaminants - polybrominated diphenyl ether (PBDE), perfluorooctanyl sulfonate (PFOS), and perfluorooctanoic acid (PFOA).

Preliminary results indicate that PCBs (0 to 320 ppb) and DDE (1.3 to 84.0 ppb) in Lake Superior continues to decline from highs in the 1980s. However, we found unmetabolized DDT in three of 10 nestlings on Lake Superior and one of 26 from inland areas. The unmetabolized DDT suggests a recent source of this chemical, which was banned in North America in 1972. Mercury concentrations were lowest in Lake Superior and Greater Twin Cities (range 1.0 to 4.9 ug/g) and highest along the upper portions of the St. Croix and Namekagon Rivers (range 4.9 to 13.6 ug/g) where extensive wetlands contribute to methylmercury production. Lead was highest in nestlings from the Twin Cities area (range 0.3 to 3.7 ug/g), but generally low elsewhere (< 0.5 ug/g). We found PBDEs in all nestlings sampled and our data suggest a near doubling along the south shore of Lake Superior over the last five years. Levels of PFOS were highest in the Greater Twin Cities area (range 331 to 2,800 ppb), followed by the Lake Superior nests (range 11 to 330 ppb), and lowest in the upper St. Croix river system (< 40 ppb in 2006). Preliminary analysis of the 2007 results suggest that this chemical declined precipitously in eaglets from the Greater Twin Cities and St. Croix River, but remained about the same in eaglets from Lake Superior.



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Poster Abstract

Implementation of a Long-term Vegetation Monitoring at Grand Portage National Monument, Grand Portage, Minnesota.

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The Great Lakes Inventory & Monitoring Network implemented a long-term vegetation monitoring program during summer, 2007. This program covers nine national parks around the Great Lakes region including, within the western Great Lakes basin, Grand Portage National Monument. Here, during 2007 twenty plots were established along the portage trail with data collected on tree species and DBH, shrub percent cover, down woody material, sapling abundance, and herbaceous frequencies.

All twenty plots were classified as white spruce-balsam fir-paper birch type. A total of 12 hardwood and five conifer tree species were recorded in the plots. Mean *Abies balsamea* (balsam fir) density was 727 individuals/ha. Other tree species with mean densities > 200 individuals/ha were *Acer spicatum* (striped maple, 266/ha) and *Populus tremuloides* (trembling aspen, 232/ha).

Within individual size classes, 75% of *A. balsamea* individuals were <10 cm DBH. In contrast, no *Pinus strobus* individuals \leq 17.5 cm DBH were located in plots. Density-diameter graphs showed that most species exhibited the reverse-J distribution with more individuals in the smaller size classes, although *Betula papyrifera* (paper birch) and *Thuja occidentalis* (white cedar) also did not.

Most standing dead trees were in smaller size classes so that mortality mirrored live tree distribution, although both *Fraxinus nigra* (black ash) and *P. tremuloides* displayed minimal mortality.

Twenty-seven species of shrubs were recorded, with cover in most plots surpassing 40%. There were no non-native shrubs or trees located.

The suppression of fire in the area has altered the disturbance regime, in turn promoting the increase of fir within the park. White pine is exhibiting serious, prolonged regeneration failure as a result. These monitoring data suggest that management intervention may be needed to prevent other species, such as paper birch and white cedar, from experiencing the same fate.



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Poster Abstract

Occurrence of *Ixodes scapularis* in Pictured Rocks National Lakeshore.

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Ticks were detected during radio-collaring of anesthetized mammals in Pictured Rocks National Lakeshore trapped during May to July 2001-2005. Ticks from 24 bears (*Ursus americanus*), 13 martens (*Martes americana*), and 14 fishers (*Martes pennant*) were removed and keyed to life stage and species. Twenty-seven *Dermacentor variabilis*, four *Ixodes baergi*, and six *Ixodes scapularis* were identified. *Dermacentor variabilis* were found only on bears and fishers, *I. baergi* was found only on martens, and *I. scapularis* was found only on fishers.

This is the first report of *I. scapularis* in Alger County and also the first report of fishers serving as host for *I. scapularis*.



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Poster Abstract

The Effect of Predation Avoidance on American Beaver (*Castor canadensis*) Diet and Fitness in Voyageurs National Park

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The relative use of aquatic and terrestrial food resources by American beavers (*Castor canadensis*) may be influenced by predation risk. Beavers may increase their use of aquatic resources to avoid predators, and this may affect their relative fitness.

In Voyageurs National Park in northern Minnesota, we will use a combination of live-trapping, radio telemetry, and stable isotope analysis to estimate the relative proportions of terrestrial and aquatic vegetation in beaver diets, the association between proportion of aquatic-based diet and body condition, the association between body condition and recruitment, and the association between foraging time spent in water and survival. We also will estimate trail use in response to predator urine using Trailmaster infrared monitors. Our results will elucidate whether beavers reduce predation risk by increased use of aquatic resources, and whether these aquatic resources are suitable alternatives to terrestrial resources in terms of relative fitness.



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Poster Abstract

Refinement and Application of Non-invasive Tissue Sampling and Microsatellite Genotyping in Studying White-tailed Deer (*Odocoileus virginianus*) Population Dynamics

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This research will focus on refining field collection and molecular laboratory techniques used in population estimation of white-tailed deer (*Odocoileus virginianus*). The significance of this study is that it will help establish precision of population estimates based on population genetic data, it will provide local community parks and recreation department staff with another estimate of park deer population size, and finally it will demonstrate the utility of a non-invasive technique for sampling large mammals. The research will entail a three-week period of collecting deer hair from six snares set up in Presque Isle Park of Marquette, Michigan followed by several months of molecular genetic analysis in the Lindsay Conservation Genetics Laboratory of Northern Michigan University. Data analysis will include: establishing individual genotypes of hair samples, generating a robust estimate of overall park white-tailed deer population size and comparing the genetic-based estimate to an exact count of deer made by volunteers during another researcher's (Dr. John Bruggink's) drive census.



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Poster Abstract

The Conservation and Recreation Lands Database - CARL

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In an attempt to determine how much of Michigan land is in a protected status, Ducks Unlimited and The Nature Conservancy have been collecting data for nearly three years from federal, state and local agencies, plus more than 40 land trusts. In Michigan, the CARL database maps and describes land owned by public entities, private land protected by conservation organizations, and public and private land with conservation easements, long-term contracts and similar efforts.

The CARL database presents an essential foundation for the design of greenways, conservation areas, wildlife corridors, and recreational areas by providing comprehensive spatial data on existing conservation and recreational lands. CARL will also help guide policy decisions by providing current and accurate information on the location of existing conservation and recreation lands. Land trusts and their partners can better integrate and coordinate planning and conservation efforts with a comprehensive picture of the distribution of protected areas within the Great Lakes. CARL provides a baseline measure of conservation successes and gaps, thereby enabling conservation organizations to monitor and measure the effectiveness of their activities.

Across Michigan, Ohio, Indiana, Illinois and Wisconsin, the CARL project is an initiative of the Great Lakes and Atlantic Region Office of Ducks Unlimited. In Michigan, The Nature Conservancy has partnered with Ducks Unlimited in acquiring and compiling these data. Our ultimate goal is to use CARL to guide conservation planning efforts within the state of Michigan and across the Great Lakes region.



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Poster Abstract

Monitoring restoration of a tallgrass prairie, Indiana Dunes National Lakeshore

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Tallgrass prairie restoration is a challenging task in which monitoring plays an important role. Fire has been the primary treatment for this prairie restoration; however, it appears limited in its effectiveness. Monitoring results reveal truncated progress with fire alone due to an abundance of exotic and invasive species. These species resist fire, or prevent it from occurring. Results also show that yearly fluctuations in rainfall cause variable plant responses, potentially masking positive or negative effects in the short term. Used in conjunction with fire, a variety of cultural treatments such as mowing, herbicide applications, and seeding are helping to control these problem species. Without substantial reductions in these undesirable species, increases in native populations can not be expected. Monitoring the progress by treatment type will help us fine tune restoration efforts.



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ORAL PRESENTATION ABSTRACTS



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Oral Abstract

Avian Response to Human Trail Use in Pictured Rocks National Lakeshore

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Many protected or preserved wild areas are managed for both wildlife habitat and human recreational activity. The prevalence of dual use of forested lands has created concern about how management of recreational activity may impact wildlife. Birds are of particular concern, as their reproduction, survival, and habitat use respond to human activity, although responses vary by species. We examined forest bird response to human activity on trails in Pictured Rocks National Lakeshore in the Upper Peninsula of Michigan. Avian community characteristics (diversity, density, and abundance) were derived from line transect bird counts, which we conducted weekly on 11 trail transects in a northern hardwood forest from late May to early August in 2006 and 2007. We quantified human activity along transects with infrared trail monitors and used regression to test for relationships between bird communities and human activity. We examined the relationship between nest distance from the trails and activity of nest predators using artificial nests during July 2006. Thirty artificial nests were set per transect; 10 each at 0-1 m, 1-5m, and 5-15 m from the trail. Nests contained a clay egg and a quail egg and were checked for depredation every 4 days for 12 days. We used analysis of variance to examine whether depredation and prevalence of predator groups varied with nest distance from the trail.

Regression was used test for a relationship between depredation and human use. Preliminary results show little evidence that trail use impacts bird abundance, richness, or diversity. Human use had no significant impact on richness and abundance, although it was positively associated with diversity. Depredated nests were found in all 3 distances zones from the trails. We found depredated nests on all transects on days 4 and 8, but no new depredation events were identified on day 12. The average proportion of nests depredated in each zone was similar, ranging from 0.277 to 0.375 on day 4 and from 0.300 to 0.381 on day 8.

Our initial results indicate that current visitor use of Pictured Rocks is not adversely impacting birds, although continued monitoring is recommended. Our results should be useful to land managers who must consider conservation of wildlife habitat when making decisions regarding trail construction and use.



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Oral Abstract

Mercury and Methylmercury In Small Lake Ecosystems In Voyageurs National Park, Minnesota

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Mercury in fish in small lakes in Voyageurs National Park is of ecological and human-health concern. Questions of interest to Park managers and the visiting public can be addressed with data from recent (2000-2006) studies of mercury and methylmercury in small lake ecosystems of the Park.

Which lakes have high concentrations of mercury? There is about 10-fold variation in length-standardized (55 cm) concentrations of mercury in northern pike among the lakes. Concentrations of methylmercury in the water column and mercury in fish were strongly and positively correlated with dissolved organic carbon (DOC), and negatively correlated with Secchi transparency. Although not a substitute for fish-consumption advisories, recreational anglers might be informed to minimize consumption of fish from high-DOC, “tea-colored,” turbid lakes because those lakes have highest mercury levels. In contrast, lakes with low DOC concentrations (little color from humic acids) and high clarity had lower methylmercury in water and fish.

Does a fire in the watershed exacerbate mercury in the lake? Data from Shoepack Lake, which was subject to a fire in the watershed during 2004, showed a marked decrease in mercury in the soils surrounding the lake. However, concentrations of mercury in the water column and fish did not change markedly after the fire compared data from 2000-2003.

Are mercury concentrations in Park lakes increasing or decreasing? Mercury in the water column was typically sampled in spring, mid-summer, and late summer from 2000 to 2006 in four Park lakes (Shoepack, Ryan, Brown, and Peary). Although this is a fairly short time in which to examine trends, there were significant ($p < 0.05$) decreases in water-column methylmercury in three of the four lakes. However, there was no evidence of change in mercury concentrations in age-1 (approximately 1 year old) yellow perch from these lakes during the same period. Reductions in water-column methylmercury could be due to decreases in mercury deposition, variation in rainfall (which could influence extent of inundation of wetland soils—a primary zone of mercury methylation), or changes in rates of methylation and demethylation. It is unclear why mercury concentrations in age-1 yellow perch did not display temporal trends similar to the water column. These lakes could serve as useful sentinel lakes to track long-term trends in mercury in the Park.



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Oral Abstract

Using GIS to Determine Canada Yew (*Taxus Canadensis*) Abundance, Distribution, and Soil and Vegetation Relationships at Apostle Islands National Lakeshore

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Canada yew (*Taxus Canadensis*) was historically more prevalent in the Great Lakes area than it is today. Various land uses over time, including logging, subsequent fires, and increasing populations of white-tailed deer have extirpated Canada yew in many areas. The island nature of the Apostle Islands National Lakeshore promoted an even more complicated history but one in which Canada yew still exists. The history of deer in the park was quite variable from none on some islands to significant populations that nearly decimated Canada yew populations on others. Recent invasions of deer to Sand and York islands have resulted in negative impacts to Canada yew (Smith 2006) which prompted this investigation. Objectives of the investigation were to use GIS to determine the distribution and abundance of Canada yew on a landscape level, determine whether or not Canada yew is associated with specific soil and vegetation types, and ascertain whether any locations for potential restoration of Canada yew could be identified.

Between 1991 and 1992 a systematic inventory of the parks vegetation was completed in 1,416 plots (100 square meters) established across 18 islands in a grid pattern (Judziewicz and Koch 1993; the mainland unit, Eagle, Gull, and Long Islands were not included). As part of that work the presence and percent cover of Canada yew were noted in each plot. For the present report these maps were digitized and integrated into GIS and a "Flora Plots" data layer created. Plot data including presence and percent cover of Canada yew as well as tree species were analyzed in conjunction with soils in ArcMap. Island results indicated that Canada yew was broadly distributed across the park but ranged widely in cover (0.5 to 89%). Those islands with a higher percent of plots supporting yew also had higher average percent cover of yew. Canada yew was associated most often with areas of finer textured soils such as sandy loam or loamy sand and in moderately well to somewhat poorly drained soil types. Yew was most strongly associated with mountain maple, white cedar, and yellow birch. Canada yew was more prevalent in old growth and it exhibited higher cover values. Finally, using GIS as a tool to identify potential sites for restoration was successful; Basswood, Oak, and Stockton Islands could all serve as candidate areas.

Smith, Douglas. 2006. Apostle Islands deer survey – 2005. Report to Apostle Islands National Lakeshore. Bayfield, WI.



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Oral Abstract

Development of a Lake Superior Basin Amphibian and Reptile Monitoring Program

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Declines in amphibian and reptile populations resulting from human activities have been reported from many regions of the world. Development of effective monitoring programs is of fundamental importance in determining the status of species and documenting changes in their abundance and geographic distribution, especially in response to rapid climate change.

The Great Lakes Region is one of the most heavily human-impacted regions globally; however, knowledge of the status of Lake Superior amphibians and reptiles is incomplete and lacks coordination. We tested six monitoring methods for amphibians and reptiles in 2006 and 2007 in four representative sampling areas in both the northern (Canadian) and southern (United States) Lake Superior Basin. We performed intensive surveys, over-sampling to develop detection probability statistics for each method and species, and applied proportion-of-area-occupied modeling to correct for likely false negatives in occupancy. This methodology allows the use of data from existing, less robust, monitoring programs (i.e. calling frog surveys) for large scale analyses. We identify overlaps in methods for detecting species and make recommendations for achieving best return on effort for monitoring programs.

Direct benefits of the project include providing helpful information to numerous organizations in the United States and Canada for conservation, management, education, and citizen monitoring programs, detailing what species of amphibians and reptiles can be effectively monitored, by what methods, the minimum sampling effort needed, and how to sample for multiple species in the most efficient manner. Our results will benefit both inventory and monitoring programs, providing confidence intervals for presence-absence surveys.



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Oral Abstract

Forest Ecosystem Conservation and Restoration: Seney National Wildlife Refuge and Kirtland's Warbler Wildlife Management Area

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The U.S. Fish and Wildlife Service National Wildlife Refuge System (NWRS) represents our nation's attempt to conserve, preserve, and restore lands for the wildlife they support. Currently, the NWRS consists of 548 refuges that comprise nearly 100 million acres. However, at most refuges in the Great Lakes States, existing forest conditions are considerably altered and poorly emulate stand-level composition and structure of pre-European settlement forests. We use Seney National Wildlife Refuge in the Upper Peninsula of Michigan and Kirtland's Warbler Wildlife Management Area in the northern Lower Peninsula as two case studies in which applied research is directly integrated into contemporary forest ecosystem conservation and restoration.

At Seney, research funded by the federal Joint Fire Science Program and conducted with colleagues at The Ohio State University (OSU), the U.S. Forest Service Northern Research Station, and Michigan Technological University is being conducted to better characterize the variability in the pre-European settlement, post-settlement, and post-Seney establishment fire regimes and their impacts on mixed-pine forest structure and composition. Results suggest strong linkages among fire history, management intensity, and stand structure, composition, and fuel loadings. Moreover, findings from this research are being used to develop ecologically-based restoration guidelines and guide forest silvicultural treatments aimed at mixed-pine forest restoration. At Kirtland's Warbler Wildlife Management Area, ongoing research and management are concerned with broader, multi-species and ecosystem benefits of intensive jack pine management for the Kirtland's Warbler (*Dendroica kirtlandii*), an endangered, neotropical migrant songbird. Research conducted with OSU demonstrated that each of three age classes of jack pine provided benefits for different bird species of conservation priority, from openland species in recently harvested stands to species of mature, close canopy forests in older (> 40 years old) jack pine stands. Other research with Central Michigan University involves documenting the efficacy of mechanically creating snags and downed coarse woody debris and quantifying the multi-species use of this enhanced structure.



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Oral Abstract

Understanding the Combined Importance of Species Diversity and Genetic Diversity for the Restoration of Sand Dune Ecosystems

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The Great Lakes sand dunes are an ecologically unique ecosystem that provides habitat for hundreds of rare and endemic plant and animal species. Due to anthropogenic pressures such as development and sand mining, dune habitat is being lost at an alarming rate. Despite decades of ecological research suggesting that greater biodiversity increases ecosystem functioning and stability, current restoration practices generally focus on restoring one commercially-available genotype of the dominant dune-building grass species, *Ammophila breviligulata*. Furthermore, it is unknown how different levels of biodiversity interact to promote healthy ecosystem function. For example, restoring high levels of plant species diversity and high levels of genetic diversity within plant species may interact to promote healthy ecosystem functioning.

To clarify these issues, I am simultaneously manipulating genetic diversity and species diversity in experimental restoration plots at Sleeping Bear Dunes National Lakeshore. Genetic diversity treatments of either 0, 1, 3, or 6 genotypes of *Ammophila breviligulata* are crossed with species diversity treatments of either 0, 1, 3, or 6 other species. Data will be collected on primary productivity, community stability, community diversity, soil nutrient use, sand stability and successional trajectories over the course of three field seasons. By applying basic ecological research to a restoration setting, I hope to provide new and tangible recommendations to land managers for successful dune restoration



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Oral Abstract

Using Diatoms and Paleolimnology for Biomonitoring in the Western Great Lakes National Parks

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For environmental monitoring programs it is important to have an understanding of natural fluctuations with which to compare modern measurements and trends. However, reliable long-term data sets are generally unavailable. To overcome this challenge, the Great Lakes Inventory and Monitoring Network (GLKN) is using a novel approach coupling paleolimnological analysis of sediment cores with modern sediment and water quality sampling in the network parks (Voyageurs, Isle Royale, Grand Portage, Apostle Islands, Sleeping Bear, Pictured Rocks, Indiana Dunes, St. Croix, Mississippi).

Index lakes have been identified within each GLKN park for water quality and biomonitoring. Each lake is sampled for water quality 3-4 times per year. Second, a single surface sediment sample is collected from index lakes during fall sampling; this sample integrates spatial/temporal variability of diatom production. Third, long cores (~200 years) have been taken from 1-3 lakes in most parks. Biogeochemistry, radioisotopes, and diatoms in the cores are analyzed to recreate the historical record of change in park lakes. Diatoms provide first, a biological measure of change and second, by applying calibration models, quantitative reconstructions of water quality. Finally, all modern and future sampling of sedimented diatoms will be placed in a spatial and historical context to evaluate environmental trajectories, identify stressors, and determine rates of change and recovery.

Field year 2006 focused on Voyageurs National Park. Water quality sampling targeted 22 inland lakes and long cores were recovered from Ek, Peary, and Cruiser Lakes (SLBE). Water quality and diatom community variation across the park and historical and recent environmental trajectories of VOYA lakes will be presented.



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Oral Abstract

The Use of Technology in Natural Resources Education

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The impact of technology within natural resources education programs is a pertinent topic to land managers and educators. This study researched the impacts of a remotely operated vehicle (ROV), an underwater robot, in a variety of environmental education programs that had participants from a wide range of backgrounds and ages. Participants from age 12 to 86 were allowed to either observe or operate an ROV in connection with environmental education programs. This study was conducted with partners in the National Park Service, US Forest Service, and non-profit environmental organizations. Of approximately 3,000 participants, 324 completed surveys were analyzed. The instrument included quantitative and qualitative questions. Survey results indicated that participants had a very positive view towards the use of underwater ROV technology to increase their understanding of the underwater natural resources connected with our public lands. This dissertation research study was conducted at sites in the Great Lakes, Florida, and Virginia



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Oral Abstract

Methylmercury Dynamics and Bioavailability in Wetlands of the Indiana Dunes National Lakeshore and Grand Calumet Watershed

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Indiana Dunes National Lakeshore (INDU) is located along the southern shore of Lake Michigan in a region known to have been impacted by atmospheric pollutants emitted from nearby heavy industries. A large portion of INDU also lies within the Grand Calumet watershed, which has been designated a Great Lakes Area of Concern in part due to the legacy Hg contamination in its streams and lacustrine wetlands. As a part of an effort to delist water bodies within the watershed, a survey of MeHg in water, sediments and fish was conducted in ~30 lacustrine wetlands during the summer of 2006. In addition, a seasonal study of MeHg in water and sediments of 9 wetlands, one of which is a restored system, in INDU and the Grand Calumet was conducted in 2007. Finally, a small-scale field test of a new method for passively sampling bioavailable MeHg in surface waters was performed using volunteer and park service personnel. The results presented in this talk will focus on the observed dynamics and controls on dissolved MeHg in surface waters within and near INDU. Strong correlations with geochemical variables particularly pH and DOC and season were observed for the dissolved MeHg data. Some of the highest levels of MeHg were observed in the constructed wetland, which also has extremely high (>40 mg/L) DOC. Of particular interest is our preliminary study of the passive sampling devices for MeHg developed by Clarisse and Hintelmann (2007). The DGT probes can be deployed by park personnel and readily shipped and analyzed at a reduced cost as compared to water samples. Results obtained with these devices were consistent with the suggestion that association with natural dissolved organic matter makes MeHg less bioavailable. Beyond the monitoring aspects of the survey, this study has served as the first field test of a novel set of methods for analyzing MeHg in environmental samples: water sediments and biota. The new methods are based on an entirely different analytical system than is typically used in studies MeHg in the environment. The coherent geochemical patterns in our findings support the validity of these new analytical methods, which other recent studies are also showing are equal to or superior to conventional methods. The ease with which the system can be automated suggests that its use can help reduce the analytical costs of Hg studies in the future.



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Oral Abstract

Relationships Between Forage Availability and Moose Numbers at Isle Royale Based on Data from a Long-Term, Island-Wide Sampling Network

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Moose depend more on woody plants than does any other member of the deer family; hence they have considerable potential to alter plant communities dominated by trees and shrubs. In winter, moose feed on current (and some older) twigs of deciduous woody-plants plus foliated twigs of some conifers. In summer they strip leaves and twigs from deciduous species but seldom use conifers. In winter moose at high densities can prevent tree saplings from growing above their reach (ca.2.8-m); however, their leaf-stripping in summer is probably even more stressful to the vigor of tree samplings. At Isle Royale since the late 1920s, except after extensive fires in 1936, moose have prevented most saplings of their highly preferred species— quaking aspen, white birch, mountain ash, pin cherry, and red maple, from reaching mature, seed-bearing size; also they partially suppress the common but slightly less-preferred balsam fir, yellow birch, and sugar maple. In our studies on the island, a long-term objectives has been to quantify the degree to which moose alter the normal course of succession in the forests, both northern-hardwood and boreal.

From our data, some going as far back as the 1960s, we cover two aspects: to describe our island-wide sampling network for tracking ecological variables related to moose-forest interactions, and to present analytical results that link trends in moose numbers with availability of forage over a 23-year span. We conclude with a recommendation that our sampling program ought to be continued because of its past and future relevance to current objectives of the Park Service.

Our sampling network, developed incrementally from 1963 to 1997, comprises 631 points at which 20 different measurements are taken repeatedly at varying time intervals. Data are collected within circular plots of radii that vary with the data type. Points are marked for relocation, so that repeated measures are always at the same site. They are grouped into 57 clusters of mostly 10 points each and spaced at 61-m along straight lines. Clusters in turn are spaced somewhat evenly along each of 12 transects lying perpendicular to and spaced somewhat evenly along the island's long axis. Thus this pattern provides an overall coverage that is roughly symmetrical. It would appear that, for interpreting sample data, the number of independent observations is no more than that of clusters, 57, since points within each cluster would, by definition, be spatially associated. However, testing shows that, relative to the mapped forest types of the island, our 631 points actually sample forest types as representatively as would a set of 1000 purely random points.



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Oral Abstract

Does Adult Body Condition Affect Recruitment Potential in Lake Whitefish (*Coregonus clupeaformis*)?

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Since the 1990s, declines in body size of lake whitefish *Coregonus clupeaformis* in northern Lake Michigan have been coupled with reduced condition. The impacts of declines on recruitment were analyzed from six sites in Lake Michigan and one site each in Lakes Erie and Superior. Relative condition differed among mature lake whitefish in 2004 and 2005, but those relationships varied by stock. Growth of adults was greater in Lake Superior than in Lakes Michigan or Erie. Fish from each lake had distinctive fatty-acid (FA) profiles. Although Lake Erie fish had the highest muscle lipid concentrations, they ranked the lowest and Lake Superior ranked the highest in terms of overall FA quality (ratio of omega-3 to omega-6 FA). Within Lake Michigan, fish from Naubinway had the lowest essential FA concentrations. Levels of DHA (a FA found in high concentrations in *Diporeia* and *Mysis*) were lowest in Lake Erie fish and highest in Lake Superior fish. At the stock level, egg moisture, energy density, and energy content differed between years and among stocks. Females from Lake Superior produced the largest eggs and had the lowest relative fecundity, while females from Lake Erie produced the smallest eggs and had the highest relative fecundity. Across lakes, total fecundity and egg size were not influenced by maternal condition, but were influenced by gonadosomatic index. Among Lake Michigan sites, females with higher omega-3 to omega-6 FA ratios produced fewer, smaller eggs. Mean daily growth rates of juvenile fish collected in June differed among stocks and between years. At the lake-basin level, age-0 juveniles from southern Lake Michigan grew faster than northern Lake Michigan or Lake Superior stocks in 2005 and 2006. Energy density of juvenile lake whitefish did not differ between years, but did differ among stocks.



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Oral Abstract

Fire and Fire Surrogate Treatment in Red Pine and the Impact on Fungal Disease and Red Turpentine Beetle at Muskrat Lakes, Luce County, Michigan

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This project is studying the effects of fire and harvesting on insects, pathogens, and understory diversity in naturally regenerated red pine, *Pinus resinosa*. The design is modeled after the national Fire and Fire-Surrogate study, and treatments include fire only, mechanical harvesting only, combination of fire and harvesting, and untreated control areas. In 2004 and 2005, pre-treatment data were collected from twenty 0.04-hectare plots in each of twelve 10+ hectare treatment areas. All trees in these plots were measured and tagged. Spore traps measured the presence of shoot blight fungi in the genera *Sirococcus* and *Diplodia*. Treatments were applied in 2005-2006, with mechanical harvesting occurring in fall 2005 and prescribed fire treatments carried out in spring 2006. Post-treatment data were collected in summer 2006 and again in 2007. Damage by red turpentine beetle (*Dendroctonus valens*) was evaluated. Prior to treatment application, signs of red turpentine beetle attack were rare. Following treatment in 2006, over 25% of cut stumps were attacked by red turpentine beetle in both burned and unburned harvested areas.

In 2006, the highest attacks in standing trees occurred in the harvest and burn combination treatment areas. Lower attack rates occurred in other non-control treatment areas and control treatments had no beetle attacks.

In 2007, the proportion of standing live trees attacked was significantly higher in both the burn only and the burn combined with harvest treatment areas than the harvest only or control. Attack rates in cut stumps did not differ between burned and unburned harvested stands. These data suggest that attacks on live trees are related to fire, while the infestation of stumps can occur independently of fire. Shoot blight pathogens were assessed before and after the treatments were applied.

In 2006, *Sirococcus* spore counts were significantly lower in burned treatment areas than harvest only and control and also significantly lower in harvest treatments than control. *Diplodia* spore catches did not differ significantly between treatments and control. The treatment prescriptions are of the type that may be utilized on a large scale in red pine forests with goals of achieving structurally diverse stands containing multi-aged trees. Evaluation of the impacts of these treatments on forest vegetation, insects and pathogens will continue into the future. A similar investigation will begin this spring in the area burned by the Sleeper Lakes wildfire.



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Oral Abstract

Age and size structure of coaster brook trout in Pictured Rocks National Lakeshore, Michigan, USA

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The adfluvial migratory form of brook trout, locally called coasters, is endemic to the Lake Superior drainage. Severely depleted by the early 1900 s, restoration efforts are now underway across the watershed.

In Pictured Rocks National Lakeshore, we have been studying wild brook trout that exhibit the coasting behavior without apparently attaining the large sizes historically associated with coasters. Previously, we have demonstrated movement peaks between lake and stream in spring and, particularly, fall. The proportion of coasting individuals in the restoration streams ranges from 5-20%. Using scale analysis combined with RFID telemetry, we have now found that adfluvial brook trout are primarily age 1 (77%) with some age 2 (15%) and age 3 (7%) at the time of movement. Additionally, there was no difference in the length-at-age or condition-at-age of resident and coasting brook trout. This data suggests that initiation of coasting may not be linked to juvenile growth-at-age parameters in these systems and that other environmental issues may be important in determining the life history strategy adopted.



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Oral Abstract

Use of OSL, GPR and GIS to Constrain Behavior of Lake Minong's Water Plane and Paths of Meltwater Discharge Across Eastern Upper Michigan, USA.

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Hundreds of now-stable, parabolic dunes are widely distributed across the low-relief plains of interior eastern Upper Michigan (EUM). We derived 85 optical (OSL) ages on quartz sand from dunes scattered throughout EUM. Results indicate that most of the dunes we sampled were stabilized during the early Holocene, ~10.4 - 8.5 ka. We suggest that dune activity in the Big Two-Hearted, Betsy and Tahquamenon Valleys (draining to Lake Superior) was initiated as the water plane of Lake Minong fluctuated and fell, exposing sandy lake beds to deflation. The fact that dunes of similar age are spread SW beyond the height of land at Danaher to the Manistique River watershed (draining Lake Michigan) is puzzling and requires a mechanism for sand nourishment that is independent of the Lake Minong water plane.

To connect our data set with possible explanations, we used GIS to reconstruct rebound-adjusted paleotopography and ground penetrating radar (GPR) to explore subsurface stratigraphy at Danaher. Prior interpretations notwithstanding, GIS demonstrates that, with the Nadoway Barrier intact, the initial outlet of Lake Minong could have stood near Germfask (just SW of Danaher) and drained across the Manitoulin Dolomite SW to Lake Chippewa. This would afford a mechanism for of landscape scouring and a possible sand source for dunes. An OSL age on near-planar bedded sand at Danaher suggests that the site drained (was abandoned as an outlet?) ~10.3 ka. This presumably occurred as retreat of the LIS permitted drainage of the Superior Basin to the northeast and a drop in the level of Lake Minong. GPR reflections at Danaher suggest glaciofluvial sediments that accumulated in Lake Minong prior to abandonment of the Germfask spillway. Those sediments lie beneath several younger sequences we interpret as representing shallow wedges of sandy sediment that were episodically stranded above the standing level of Lake Minong during lake level fluctuation. Rebound of the northerly outlet would have caused a slow transgression of the lake and subsequent changes in meltwater receipt into the Superior Basin may have driven brief spillovers though Danaher and Germfask to Lake Chippewa. Rebound eventually led to the overtopping or sapping-through of the Nadoway Barrier, the destruction of Lake Minong and the establishment of modern drainage ~ 9.0 ka.



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Oral Abstract

Three Decades of Water Quality Change (1976-2005) in the Mississippi National River and Recreation Area

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The Mississippi National River and Recreational Area (MNRRA) spans a 116 km stretch of the Mississippi River in the Twin Cities Metropolitan Area. Although many agencies monitor Mississippi River water quality, none has analyzed or interpreted the data with specific respect to MNRRA.

To understand park-specific water quality trends, we compiled thirty years of Metropolitan Council monitoring data (1976-2005) for six Mississippi River sites, a nearby Minnesota River site, and the Metropolitan Wastewater Treatment Plant outflow. Data showed strong spatial trends, with increasing concentrations of nutrients and sediments from upstream to downstream, and strong temporal trends, with significant decreases (as per seasonal Kendall trend tests) in the flow-adjusted concentrations of most nutrients, total suspended solids, and turbidity over the period of record at all sites. Only nitrate concentrations increased significantly over time. Water quality in MNRRA appears highly sensitive to changes in both wastewater treatment and tributary inputs.



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Oral Abstract

Overview of State and Private Forestry (S&PF), with Emphasis on Forest Health Protection

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The presentation provides an overview of S&PF, the various types of assistance available, and examples of projects that have historically received funding.

S&PF is one of three branches of the USDA Forest Service. S&PF in the Northeastern Area provides technical and financial assistance to twenty Northeastern and Midwest states. Our primary cooperators are state Departments of Natural Resources. Our Forest Health Group also is responsible for providing forest health assistance to all federal land management agencies, as well as tribal lands.

Forest Health protection has a staff of entomologists, pathologists and foresters. Our technical assistance is provided on a request basis. Our staff also conducts aerial surveys each year to document pest activity on federal and tribal lands. The results of these surveys are provided on the NA website located at: <http://www.na.fs.fed.us> . You may also request paper copies of this survey information.

In addition to technical assistance, financial assistance requests for specific forest health projects are considered and provided on a "project by project" basis. These project requests are solicited by a call letter each year in late summer to early fall. Before funding can be provided a forest health staff member must conduct a biological evaluation that documents the pest activity and recommends intervention to manage the pest.



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Oral Abstract

Investigating Sources of Variability in Quadrat Sampling of Wetlands at Voyageurs National Park

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In our goal to establish a baseline and long term monitoring recommendations for vegetation in Voyageurs National Park wetlands, we estimated sources of variability in the sampling of vegetation data in a number of general categories. In this talk we will present our results in estimating three sources of variance in our sampling of: 1) Intra-observer bias, that is, the sampling variability inherent in estimates made by a single, experienced observer repeatedly sampling the same resource, 2) Inter observer bias, by looking at how different observers and their experiences in sampling may contribute to variability in results, and 3) what we have called placement variability, an attempt to determine the minimum number of sub-samples (in our case quadrats) needed to produce reliable information.

Each of these three sources of variability in sampling was estimated by using 1m x 1m quadrats placed along transects at three different habitat types: peatlands, shorelines, and aquatics (1.0m to 2.0m). The quadrat sampling provides numerous metrics to assess, including summary statistics, such as mean species richness per quadrat and overall quadrat cover, as well as metrics for individual taxa, such as cover, frequency, and importance value (in this case the mean of relative cover and relative frequency).

In addition, we have developed two metrics of importance to monitoring. One metric we have called minimal detectable change for individual species that suggests what level of changes in abundance will need to be observed between sampling times to be considered significant or real. The other metric we have called detection accuracy which compares the ease of accurate detection among different taxa.



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Oral Abstract

Development of a Continuous, Flow-through Test System to Chronically Expose Juvenile Unionid Mussels to Pharmaceutical Compounds

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As part of a parent project to determine the effects of pharmaceuticals and personal care products found in the St. Croix National Scenic Riverway, we are developing a test system to conduct chronic laboratory toxicity trials with juvenile mussels. To determine a feeding regimen for the test system, 1- day old, plain pocketbook mussels (*Lampsilis cardium*, 40 per chamber) were transferred to test chambers containing 200 mL of well water and 25 g of silica sand. The test system contained 2 sets of 30 chambers, each with a flow rate of 5 or 10 mL/min. In each flow rate group, each of 6 food types were replicated 5 times. Food types were (1) Nannochloropsis 3600 Instant Algae®, (2) Shellfish diet 1800® Instant Algae®, (3) Upper Midwest Environmental Sciences Center (UMESC) daphnia diet, (4) a combination of Nannochloropsis and Shellfish diet, (5) a combination of Nannochloropsis and UMESC daphnia diet, and (6) a combination of Shellfish diet and UMESC daphnia diet. The nominal water temperature was 21°C. On days 17 and 38, 1 chamber of each food type from each flow rate group was surveyed for live mussels. On day 56, all remaining chambers were surveyed for live mussels. Live mussels were retained for growth measurements. By day 56, chambers receiving food types 3 and 6 held no live mussels. Only 4 chambers of food type 2 and 2 chambers of food type 5 held live mussels. All chambers receiving food type 1 (48% survival, 31% *rsd*) and food type 4 (27% survival, 53% *rsd*) held live mussels. Flow rate did not affect survival.

The mean length of 1 day old mussels was 267 μm (5.0% *rsd*). After 56 days, the mean length of mussels offered food type 1 at 5 mL/min was 927 μm (15% *rsd*) and at 10 mL/min was 991 μm (24% *rsd*). Growth rates were 11 and 12 $\mu\text{m}/\text{day}$, respectively. The mean length of mussels offered food type 4 at 5 mL/min was 888 μm (25% *rsd*) and at 10 mL/min was 1054 μm (27% *rsd*). Growth rates were 11 and 14 $\mu\text{m}/\text{day}$, respectively. In this test system, the Nannochloropsis food type resulted in the greatest survival. Nannochloropsis and a combination of Nannochloropsis and Shellfish diet resulted in growth rates similar to previously published growth rates of mussels reared in laboratories.



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Oral Abstract

Factors Contributing to Type E Botulism Outbreaks at Sleeping Bear Dunes National Lakeshore

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In autumn of 2006, a large die-off of native fish-eating birds occurred in Lake Michigan, almost exclusively within the boundaries of Sleeping Bear Dunes National Lakeshore. Nearly 3,000 dead birds were documented, along with many fish. Necropsies of a subset of the dead birds indicated type E botulism poisoning. Recent changes in nearshore food webs, associated with invasive dreissenid mussels and round gobies, have been implicated in this resurgence of type E botulism, which is also occurring on several of the other Great Lakes as yearly events involving the die-off of thousands of native birds and fish. Four individuals of the endangered Piping Plover species were included in the 2007 die-off along with hundreds of individuals of state listed species including the Common Loon and Common Tern.

The hypothesized pathway begins with dreissenid mussels facilitating the excess growth of *Cladophora*, a native benthic macroalga, by increasing water clarity and nutrient regeneration. Dense beds of decaying algae or dead/dying dreissenid mussels appear to create nutrient-rich, anoxic conditions on the lake bottom, which facilitates the growth of *Clostridium botulinum* and the production of the type E toxin. *C. botulinum* is nearly ubiquitous, but its toxin is only produced under conditions of anoxia and high nutrients facilitating the metamorphosis of the bacterial spore to a vegetative state. The toxin is then concentrated by dreissenid mussels or macroinvertebrates, which are consumed heavily by the round goby, and passed via the infected gobies to piscivorous fish and fish-eating birds.

During summer 2007, a study was commenced at Sleeping Bear Dunes National Lakeshore to explore the hypothesized pathway for botulism transfer to fish and fish-eating birds, by continuously monitoring key water chemistry conditions on the lake bottom (temperature, pH, conductivity, and dissolved oxygen), determining toxin concentrations in food web components suspected in botulism transfer, determining toxin concentrations in dead fish and fish-eating birds, documenting gut contents of dead fish-eating birds, and assessing trophic connections via carbon and nitrogen stable isotope analysis. Results will provide insights into conditions facilitating toxin production and clarify the potential for several benthic food web components to contribute to trophic transfer of the toxin to birds. A review of the 2006 and 2007 dieoffs within SLBE boundaries and around northern Lake Michigan will also be presented.



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Oral Abstract

Forty-seven Year Changes in Vegetation at the Apostle Islands: Effects of Deer on the Forest Understory

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White-tailed deer (*Odocoileus virginianus Zimmerman*) have been labeled a keystone herbivore in forests of the Midwestern United States, particularly as deer have increased over the past century due to forest fragmentation, reduction of natural predators, reduced hunting, and mild winters. Deer browsing in the Apostle Islands National Lakeshore has had a pronounced effect on formerly large continuous patches of reproductive Canada yew (*Taxus canadensis Marshall*) found there.

In this study we resurvey 32 forest sites on the Apostle Islands to compare understory plant communities in 2005 to those sampled in 1958. Some sites remained free of deer throughout the study period, others retained constant deer pressure, while the remaining sites gained or lost deer. Four new understory species have colonized these sites (including *Arisaema triphyllum L.* and *Maianthemum racemosum L.*), four other species increased by more than 20% (including *Rubus idaeus L.* and *Equisetum sylvaticum L.*), while 12 species decreased by more than 20%. Several of these species appear to have shifted their abundance in response to deer browse. Multivariate analyses reveal that deer have strong effects on both the rate and type of change in the forest understory. As deer remove the dominant shrub *Taxus*, other species, particularly grasses and sedges, are favored. Perennial forbs may be threatened on islands with consistent deer pressure. The impacts of deer on these understory plant communities appear to be increasing over time.



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Oral Abstract

Predictive Modeling for Invasive Exotic Plants at Pictured Rocks National Lakeshore

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Invasive exotic plants are one of the Vital Signs monitored by the National Park Service (NPS) to detect ecosystem change. To assist this monitoring, multi-criteria risk models were developed for current and potential invasive plants at Pictured Rocks National Lakeshore. The models utilize Geographic Information System (GIS) data to assess the risk of exotic plant invasion at three phases: introduction, establishment, and spread. The outputs from the models are being used to create risk maps of the Park that highlight the areas at highest risk. The maps will guide monitoring of new invasions by indicating the areas with the greatest risk of introduction and establishment, and can be used to prioritize known invasions with a high risk of spread for control treatments. Invasive plant models have been developed for baby's breath (*Gypsophila paniculata*), common buckthorn (*Rhamnus cathartica*), common reed (*Phragmites spp.*), garlic mustard (*Alliaria petiolata*), glossy buckthorn (*Frangula alnus*), honeysuckle (*Lonicera spp.*), leafy spurge (*Euphorbia esula*), multiflora rose (*Rosa multiflora*), purple loosestrife (*Lythrum salicaria*), and spotted knapweed (*Centaurea biebersteinii*). The risk maps, finished models, and user manual will be provided to the NPS for use at the nine National Parks in the Great Lakes Network.



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Oral Abstract

Threats to the Conservation of Songbirds and Understory Vegetation by White-tailed Deer (*Odocoileus virginianus*) Browsing, A natural experiment in the Apostle Islands National Lakeshore

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Throughout the western Great Lakes region populations of white-tail deer, (*Odocoileus virginianus*), are reaching historically high densities. Simultaneously, regional breeding bird surveys report declines in various ground-nesting songbird species. Bird communities are indirectly affected when deer browsing alters forest vegetation, which makes browsing a likely contributor to songbird declines. At high densities, browsing can reduce nesting habitat for shrub and ground nesting birds, increase nest predation, and limit feeding habitat for avian species that forage in forest understories. To appropriately manage habitats that will foster and maintain this region's valued bird communities, it will be important to better understand how deer browsing may affect them.

To quantify the influence of deer browsing on critical avian habitat, species abundance and diversity, a natural experimental design was created within the Apostle Islands National Lakeshore to survey island breeding bird communities at locations with various deer densities: high, low, and no deer present. In June of 2007, breeding bird surveys (10 minute point counts) were conducted on 6 islands and on the mainland for a total of 68 breeding bird points. The islands and the mainland represent various combinations of deer abundance (browsing intensity) and nest predator abundance. In July and August 2007, the breeding bird points were re-visited and vegetation data was collected at two randomly selected, two-meter-squared plots within the bird point count area. Vegetation measurements included deer browsing intensity (browsed and available stems), vegetative ground cover, leaf litter samples, and basal area of dominant canopy trees. Abundance of the Ovenbird, the most common ground nesting avian species, declined with increased browsing. But, concurrently bird species diversity increased with increased browsing. By reducing the dominance of the most abundant species in the community (the Ovenbird), it appears that browsing allowed for more equal distribution of resources among bird species and therefore a diversification of the bird community. Further statistical analysis is currently underway to better explain causal relationships between variables.



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Oral Abstract

Understanding the Past to Plan for the Future: Paleocology of the St. Croix River

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The St. Croix River, which forms much of the border between WI and MN, has undergone significant land-use changes since European settlers arrived in the 1840s. The river continues to face major ecological threats from increased recreational use, population growth, and development in the watershed. For guiding management decisions on the river, an understanding of the timing and magnitude of change in river conditions before and since European settlement is crucial and well suited to paleolimnological investigation. However, paleolimnology of rivers provides unique challenges. Sediment transport is often too episodic and complex to allow accumulation of continuous sedimentary sequences. Therefore, previous paleolimnological studies on the river have targeted Lake St. Croix (a natural impoundment of the river) and demonstrated that, despite its perception of being a pristine river, significant increases in nutrients, sedimentation rate, and algal productivity have occurred since European settlement.

Environmental impacts on the river are not limited to Lake St. Croix; for that reason, we have analyzed sediment cores from three floodplain wetlands on the lower reaches of the St. Croix River. Results from our work on floodplain wetlands, as well as work from Lake St. Croix, demonstrate that dating of sediment cores from riverine systems is extremely challenging. To provide reliable dating models for these cores, careful site selection was coupled with a combination of lead-210, cesium-137, magnetics, and pollen analyses. Once dating models were established for the floodplain wetland cores, sediment diatom communities were analyzed with decadal scale resolution for the past 250-300 years. Shifts in the diatom community structure were then correlated with the land use history of the St. Croix watershed, and compared to the changes seen in Lake St. Croix. To identify some of the drivers of change in the diatom communities we compared the changes in the cores to a large diatom calibration set for MN lakes.



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Oral Abstract

History and Status of American Marten at Isle Royale National Park

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Once common at Isle Royale National Park (IRNP), the American Marten (*Martes americana*) may have been extirpated shortly after the turn of the 20th century. From 1991 until the present, numerous anecdotal reports including tracks, sightings and photographs have been received. Although not exhaustive, I have attempted to collate from as many sources as possible both historic and more recent records to assist in evaluating the past and present status of American marten at IRNP. I examine the plausibility of a remnant population by extending the time line for which American marten were known to exist at the park. Contrastingly, I scrutinize the potential for colonization given the American marten's natural history traits, the geographical barrier of Lake Superior, and the evolution of scientific investigations that have occurred at the park. By considering that an undetected remnant population likely experienced a bottleneck brought about by over-trapping or what would be a truly remarkable immigration event, the uniqueness of this isolated population increases with regards to scientific importance and conservation, and merits further inquiry.



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Oral Abstract

Using Great Lakes National Parks for Earth Systems Education

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Earth System Science is best taught with field experiences and the National Parks of the Great Lakes region offer extended shorelines where the rock record of earth history is exposed and where active surficial processes are obvious. Use of National Parks as earth system laboratories for education is limited by the lack of earth scientists in the national park service and the lack of trained earth science teachers in schools. Lack of interpreters and teachers has resulted in a lack of public understanding of earth systems and has slowed public education about critical earth issues such as natural hazards and global change. Our group is engaged in the development of field-based educational experiences framed by an active partnership between national parks, university earth scientists and public school earth science teachers. Our efforts center on outdoor education at sites where active observations of real geological materials and processes can promote understanding of how the earth works.

Relevance of geologic information is highlighted by linking the formation and natural history of the planet to concepts such as global change and sustainability. Being outside enhances holistic perspectives because each observation must be interpreted within the framework of the entire landscape. Utility of the scientific method can be highlighted effectively outside, in the real world, where the wind, temperature and other variables are uncontrolled but can be measured and used in developing and testing hypotheses.

We have begun our effort with two graduate classes for teachers, which focus on awareness of natural hazards. We plan a full program that will empower teachers to use field sites as outdoor classrooms. By using national park sites we gain high quality settings and also have the opportunity to involve park interpreters who are aware of the social implications of parks resources. Bringing together interpreters and teachers is anticipated to result in development of new materials that can be used in both parks and schools to promote public understanding of the earth.



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Oral Abstract

Growth in Coaster Brook Trout: Seasonal and Hormonal Effect

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We compared populations (3 coasters, 1 stream resident) of Lake Superior brook trout (age 1) over time to determine if they differed in growth parameters or levels of thyroid hormones. A coaster is a brook trout that spends all or part of its time in a large lake. In Lake Superior coasters were once abundant; however, angling and habitat destruction substantially depleted their numbers. A life history variant, coasters are thought to be larger in size than the resident fish that stay in the natal streams. Four strains of brook trout were held at constant temperature ($\sim 12^{\circ}\text{C} \pm 1^{\circ}\text{C}$) and natural photoperiod. A subset of fish was sampled monthly. No significant difference was found between strain ($p=0.392$) or sampling period (month; $p=0.686$) in length based relative growth rate. However, there was a significant difference in condition factor across the sampling periods ($p<0.001$) and strains ($p<0.001$). The Nipigon strain had a higher condition factor than the Tobin Harbor, Iron River, or Siskiwit strains. We suggest that the differences in growth in field studies are most likely an environmental effect given the similarity in growth parameters seen under common rearing conditions.



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Oral Abstract

Sharing YOUR Results with Managers, Educators, and the Public; The Great Lakes Research and Education Center is Here to Help

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The Great Lakes Research and Education Center (GLREC) facilitates research in ten national parks and adjacent waters in the Western Great Lakes Region. It also provides educational opportunities for resource managers and the general public related to natural and cultural resources. Current research findings must be shared with park managers and the general public to ensure the best possible resource stewardship and continued support for research in the future. The GLREC's education coordinator works with researchers to facilitate that sharing through education, interpretation, and outreach endeavors. These efforts involve collaboration between the National Park Service and partner organizations. Examples of potential projects include newsletter, newspaper, and website articles; live meetings via internet; brochures and site bulletins; staff trainings; public workshops; teacher institutes; citizen science projects; and the development of interpretive and educational activities and programs that can be conducted by national park interpretive staffs and educators across the region.



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Oral Abstract

Cliff Regression Along the Keweenaw Bay Cliffs Near the Grover C. Dillman Roadside Park on US-41 in Baraga County, Michigan

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A section of US-41, east of the community of Keweenaw Bay and immediately south of the Grover C. Dillman park scenic turnout, runs along the top of a Jacobsville sandstone cliff for approximately a third of a mile. The cliff regression is threatening the highway as well as the Grover C. Dillman roadside park. In the fall of 2007, the guardrail had to be moved several feet in toward the road. Measurements indicate that over time the annual rate of cliff regression has been approximately five centimeters per year. However, regression appears to have accelerated during the high water levels of the 1980's. The regression results in a talus slope at the base of the cliff that has built up to approximately half the height of the cliffs and extends out to the shoreline of Lake Superior. However, wave and frost action have combined to reduce the talus material while prevailing long-shore currents moving southward towards Baraga remove the weathered materials so that a stable talus shoreline has not developed. In addition there were two stamp mills associated with the copper mining on the Keweenaw Peninsula that were built at the beginning of the twentieth century which were located north and south of the cliffs that appear to have an affected the regression rate of the cliffs.

This paper will present the results of a research program carried out to study the regression processes and to advise the Michigan Department of Transportation on corrective measures that should be taken to protect both the highway and the roadside park.



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Oral Abstract

Monitoring and Assessing Methylmercury and Organic Contaminants in Aquatic Biosentinel Organisms in the Great Lakes Network

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Aquatic food webs are important pathways for exposure of wildlife and humans to many toxic, bioaccumulative compounds. We present a protocol for monitoring and assessing spatial patterns and temporal trends in methylmercury and organic contaminants in aquatic food webs in NPS park units within the Great Lakes Inventory and Monitoring Network. For methylmercury, we will target 1-year-old prey fish, with yellow perch (*Perca flavescens*) as our biosentinel organism of choice. Other species, including green sunfish (*Lepomis cyanellus*) and larval dragonflies (Insecta: Odonata), will be sampled at sites where yellow perch are unavailable. We will target adult northern pike (*Esox lucius*) as our biosentinel organism of choice for organic contaminants, which include DDT, PCBs, PBDEs, PFOS, and PFOA. Biota for contaminant analyses will be sampled at sites where water quality is being monitored annually by the Great Lakes Inventory and Monitoring Network. This will facilitate the statistical analysis of contaminant data in relation to physicochemical and landscape metrics of surface waters and watersheds, to strengthen interpretation and develop predictive models. Information from the mercury analyses can be used to identify locations on the landscape that are characterized by elevated concentrations of methylmercury in biota that exceed criteria for protection of human health or wildlife. Moreover, the analysis of spatial and temporal patterns in concentrations of methylmercury and organic contaminants in biosentinel organisms is an important step in identifying landscape, aquatic, and human factors that control the abundance of these contaminants and the associated exposure of biota within the park units.

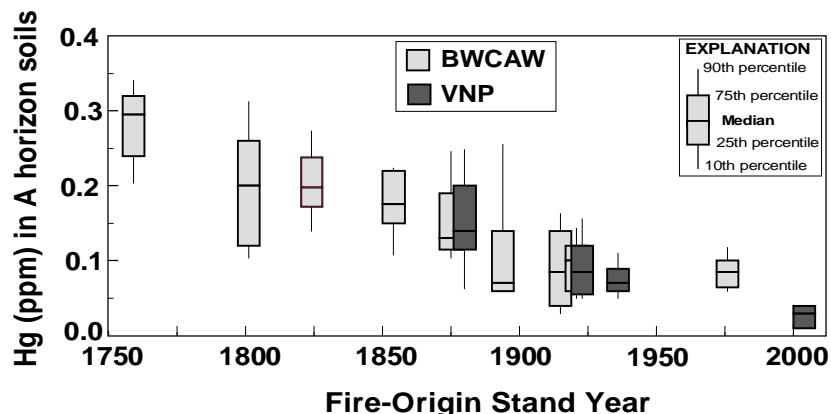
Oral Abstract

Influence of forest fires on levels of mercury in forest soils, Lake Superior Region

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In the Lake Superior region mercury (Hg) has been enriched in forest soils by long-term atmospheric deposition and sequestration of a fraction of the deposited Hg load, mostly by binding of Hg to soil organic matter in the forest floor (O-horizon) and organic mineral soil (A-horizon). Mercury cycling in forest soils is strongly influenced by forest disturbance, especially forest fires. The Section 33 wildfire, which burned over 1000 acres in Voyageurs National Park (VNP) in 2004, resulted in losses relative to adjacent unburned areas of: 1) ~ 0.22 mg Hg/m² in high fire-severity burned areas because of complete combustion of the O horizon, and 2) ~ 0.6 to 0.9 mg Hg/m² from the A horizon in these same areas. Our survey was conducted two weeks after the fire and prior to any significant rainfall and indicates that these Hg losses were an immediate and direct consequence of combustion and volatilization of Hg from the soil. Such Hg losses from soil resulting from severe wildfires are likely to be gradually ameliorated by continued atmospheric deposition and sequestration which eventually restores Hg contents toward pre-fire levels. An on-going study in the Boundary Waters Canoe Area Wilderness (BWCAW) indicates that the time over which Hg concentrations in soils can increase after a fire is many decades or even centuries. We analyzed O-horizon and A-horizon soils from 11 areas of primarily virgin boreal forest within the BWCAW that have fire-origin stand ages (time since last severe wildfire) ranging from the 1700's to the 1970's. Integrated with our VNP data, there is a statistically highly significant relationship between fire-origin stand age and Hg concentration in A-horizon soils ($r^2 = 0.870$) in which older stands have progressively higher Hg concentrations. This relationship suggests that the pattern of Hg concentrations in forest soils should form a mosaic that varies in accordance with the mosaic of wildfire-controlled stand ages. The fire-origin stand age within a watershed thus provides a means of predicting the Hg load in soils, particularly where the stand age mosaic has not been modified by other human activity.





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