

PROCEEDINGS OF THE ACADIA NATIONAL PARK SCIENCE SYMPOSIUM

Wednesday, October 26, 2011

Summary

The Acadia National Park Science Symposium, held at the Schoodic Education and Research Center (SERC), brought together 110 researchers, students, and park staff to discuss science taking place in and beyond the park boundaries. The symposium featured 5 invited talks and 56 posters describing results and plans for research in a range of disciplines, including natural sciences, social sciences, and the humanities.

Particularly well highlighted at the symposium was the relationship between science and the management of protected areas in the region. Staff from the National Park Service and U.S. Fish and Wildlife Service presented results of their own research and data collection efforts. And many researchers presented results that are already influencing management practices. For example, the National Park Service is already using the results of work done by Bob Manning and Jeff Marion to inform how they manage heavy visitor use to minimize negative impacts to natural and cultural resources and to visitor experiences.

Also highlighted was the quality of long-term records in the Acadia region and their utility in understanding the history of natural processes and human-nature interactions over the past 100 or more years. For example, Steve Norton presented results from lake sediment cores that show the history of climate change, soil development, vegetation establishment and succession, and air pollution for over 16,000 years, since the formation of Sargent Mountain Pond, the first lake in Maine to occur after the last glacial period. Catherine Schmitt presented a timeline showing the history of science in Acadia National Park. Hale Morrell showed the results of research on the natural history of Northeast Creek watershed, and Tim Garrity described the history of women's suffering in Mount Desert.

We plan to continue this symposium on an annual or biennial basis in the years to come. We hope that it continues to highlight the important research taking place in this area and to facilitate the creation of new relationships and collaborations among researchers doing complementary work.

For more information on research at Acadia National Park or SERC, please see:

www.sercinstitute.org

Abraham J. Miller-Rushing
National Park Service,
Schoodic Education and Research Center and Acadia National Park
Winter Harbor, ME

Featured speakers

Vernal pool conservation: The human-frog interface. Can we find common water?

Aram Calhoun

University of Maine, Orono, ME

Conservation of natural resources requires both good science and consideration of the human dimension of resource conservation. We use vernal pool conservation in Maine as a case study to illustrate how science and policy can be brought together to build sustainable Maine communities.

Eelgrass habitat recovery after restoration in Frenchman Bay

Jane Disney and George Kidder

Mount Desert Island Biological Lab, Salisbury Cove, ME

Eelgrass (*Zostera marina*) is a unique flowering plant, formerly occurring in widespread meadows in sub-tidal areas along the coast of Maine. As one of the primary photosynthetic producers, and as nursery habitat for many species, it plays a crucial role in the ecology of the Gulf of Maine. In Frenchman Bay, eelgrass has recently experienced significant declines, possibly related to dragging for mussels and other sessile species. At Hadley Point in upper Frenchman Bay, the bottom coverage was estimated at 60 - 80% cover in 1996, declining to <0.5 % by 2007. Over the last four summers, we have worked in partnership with multiple community groups to restore eelgrass at Hadley Point. Our efforts to date have had demonstrable success. The coverage in our restoration reserve has increased from a low of 0.5% in 2007 to approximately 15% in 2011. Moreover, while we have transplanted a total of about 74 square meters of eelgrass, a recent census revealed 3500 square meters of coverage, nearly a 48-fold increase. In addition, new eelgrass beds have developed in nearby areas of the bay. We have been tracking water currents to determine if new eelgrass areas are derived by seed dispersal from the eelgrass restoration site. Preliminary data suggest that this is the case. We have begun to assess the colonization of restored eelgrass by various marine species. Juvenile mussels are the predominant marine organism inhabiting eelgrass blades in our area during the summer months. Future plans include optimizing eelgrass restoration methods and expanding eelgrass restoration efforts around Frenchman Bay and beyond.

Parks and people: Managing outdoor recreation at Acadia National Park

Bob Manning¹ and Jeff Marion^{2,3}

¹Park Studies Laboratory, Rubenstein School of Environment and Natural Resources,
University of Vermont, Burlington, VT

²U.S. Geological Survey, Patuxent Wildlife Research Center, Virginia Tech Field Station,
Blacksburg, VA

³Department of Forest Resources and Environmental Conservation, Virginia Tech,
Blacksburg, VA

With over two million annual visits on less than 50,000 acres, Acadia National Park may be the most intensively used national park in the U.S. This has raised concerns over the ultimate capacity of the park to accommodate recreational use without unacceptable impacts to park resources and the quality of the visitor experience. Over the past fifteen years, the park has commissioned a program of research to address this issue and support application of the National Park Service's Visitor Experience and Resource Protection framework. This program of research has been designed to 1) identify indicators and standards of quality for the visitor experience, 2) develop and test protocols to monitor indicators of quality, and 3) assess visitor support for management practices designed to maintain standards of quality. Research methods include visitor observation, qualitative and quantitative visitor surveys, visual simulations, tradeoff analysis, computer-based simulation modeling, resource inventories and assessments, remote sensing, and field experiments. This program of research has been applied throughout the park, including Mount Desert Island, the Schoodic Peninsula, and Isle au Haut. Findings from these studies have supported development of a series of principles to guide management of outdoor recreation at Acadia and other units of the national park system. A book describing this program of research at Acadia was recently published by the University Press of New England.

Science and resource management at Acadia National Park

David Manski

National Park Service, Acadia National Park, Bar Harbor, ME

No abstract

Reconstructed post-glacial changes in surface water chemistry at Acadia National Park, Maine: 16,600 years BP to the near-future

Steve Norton

University of Maine, Orono, ME

A long sediment core was retrieved from Sargent Mountain Pond, Acadia National Park, Maine. The core spans 16,650 years and may represent the most complete and longest lake history of Maine's first post-glacial lake. Analyses of diatoms, pollen, lead isotopes, trace metals, and other chemical species reveal a complex interplay and co-evolution of climate change, soil development, vegetation establishment and succession, and anthropogenic contamination and recovery from recent air pollution. Data have a resolution as high as 20-30 years, enabling reconstruction of biogeochemical processes as short as decades. The lake has evolved from a high pH, eutrophic, low DOC lake to a low pH, oligotrophic, high DOC lake, over 16000 years. Recent trends in increasing atmospheric metal pollution have reversed. These interpretations, in combination with real-time water quality from atmospheric deposition and surface runoff, enable us to model the future chemical trends with fair certainty.

Poster abstracts

Potential impact of sea-level rise and climate change on seabird nesting colonies in Maine, USA

John G.T. Anderson

Island Research Center, College of the Atlantic, 105 Eden Street, Bar Harbor, ME

Islands in the Gulf of Maine currently provide nesting sites to as much as 50% of seabirds nesting in the contiguous United States east of the Mississippi. Species include Herring and Black backed Gulls, Black Guillemots, Double-crested and Great Cormorants, several species of terns, and Leach's Storm Petrels. Nesting islands in Maine are low, rocky, and subject to partial or total wash-over in major storms. With an expected sea-level rise of 1 to 1.5 meters in the next century, the National Park Service is concerned about loss of nesting species in areas under Park jurisdiction. I report here the results of initial surveys of islands owned or under easement to Acadia National Park in eastern Maine. Most islands were small, ranging from less than 2 to 20 hectares in area and consisted of heath-shrub uplands surrounded by a rocky berm. Elevation above sea-level was obtained using a survey quality total station, and evidence of nesting and species composition was recorded. While some islands have relatively steep sides and may be less vulnerable to initial sea-level rise, others proved much flatter and are at greater risk of wash-over. Species such as Black Guillemots that nest in the peripheral rocky berm and whose nesting period extends into the hurricane season are at greatest vulnerability to both sea-level rise and anticipated increase in frequency and intensity of storms.

Northeast Temperate Network freshwater monitoring at Acadia National Park

Beth Arsenault, Bill Gawley, and Aaron Rinehart

National Park Service, Inventory and Monitoring Program, Northeast Temperate Network, Bar Harbor, ME

National Park Service, Acadia National Park, Bar Harbor, ME

The Northeast Temperate Network (NETN) water monitoring program at Acadia National Park (ANP) builds on almost 70 years of water quality data collected by National Park Service (NPS) staff and researchers. The program assesses general water quality and quantity and nutrient levels of 37 park lakes and streams. As part of the NPS "Vital Signs" Inventory and Monitoring Program (I &M Program), goals include determining status and trends, early detection of abnormal conditions of park waters and providing data to better understand the dynamic nature of park ecosystems. Corresponding water monitoring data are being collected at 8 other parks in the NETN. The NETN monitoring activities compliment ongoing water data being collected at ANP including acidification sampling, macroinvertebrate analysis, invasive aquatic plant screening, and swim beach bacterial monitoring.

Lobster proximity to eelgrass beds in Frenchman Bay, Maine

Shira Bleicher^{1,3}, Elias Peirce^{2,3}, Jane Disney³, and George Kidder³

¹Wellesley College, Wellesley, MA

²Bowdoin College, Brunswick, ME

³Mount Desert Island Biological Lab, Salisbury Cove, ME

Zostera marina, commonly known as eelgrass, is a perennial marine angiosperm found in subtidal waters along many coastlines in the Northern Hemisphere. *Z. marina* plays a crucial role in the ecosystems it inhabits. The root structure, involving rhizomes that connect plants beneath the sediment, prevents small scale erosion and helps bind the sediment. The flat, tall leaves mitigate wave and current energy, and can filter nutrients from the water, and the habitat provided by a bed of *Z. marina* supports a large amount of biodiversity. A host of invertebrates inhabits eelgrass leaves and many species of crustaceans and fish use eelgrass beds as nursery areas. This study was intended to determine if there is a correlation between fish species diversity and proximity to *Z. marina* beds in Frenchman Bay. Working with a local lobsterman, species data were collected from 446 lobster traps around Frenchman Bay over a three week period, and proximity of traps to eelgrass was determined by analysis of GIS maps with eelgrass area and lobster trap coordinate overlays. There was very little fish by-catch in the traps, so an assessment of fish biodiversity could not be made. However, in an analysis of over 2,200 lobsters, small lobsters were significantly more prevalent within a half nautical mile of eelgrass beds and large lobsters were significantly more prevalent greater than 1 nautical mile away from eelgrass beds. This finding indicates the potential importance of areas around *Z. marina* as transition habitat for juvenile lobsters as they shift from a dependence on shelter to a more mobile state. Future studies will involve setting lobster traps inside and outside of eelgrass beds.

Metagenomic analysis of the soil microbiome beneath invasive Japanese barberry (*Berberis thunbergii*) plants in Maine

Vanessa C. Coats and Mary E. Rumpho

Department of Molecular and Biomedical Sciences, University of Maine, Orono, ME

Berberis thunbergii D.C. (Japanese barberry) is an invasive shrub found throughout the eastern U.S and its presence in many regions of Maine has been well documented. In the U.S., invasive plant control costs over 35 billion dollars annually, which clearly illustrates the need for research into more effective methods of control and management. Soil bacterial and fungal communities are ecologically important symbionts and they may play a role as proponents of biological invasion through assisting the plant with nutrient acquisition (i.e. beneficial bacteria and/or mycorrhizal fungi). The bacterial and fungal community diversity was investigated in soils of Japanese barberry plants from the invasive range in Acadia National Park, ME, using 454 FLX amplicon high-throughput DNA sequencing. Rhizosphere and bulk soil community profiles demonstrate the presence of all major bacterial and fungal phyla. High variation is apparent in the soil microbiota between plants within a location as well as between plants from different locations. Major bacterial phyla observed in the soils from all samples include Acidobacteria, Actinobacteria, Proteobacteria, and Nitrospirae. Fungal diversity in the soils stems largely from the three main fungal phyla: Ascomycota, Basidiomycota, and Glomeromycota. The results of this investigation provide a strong framework for comparison of the soil bacterial and fungal community profiles beneath plants in Japan, the native region where Japanese barberry is not invasive.

Submerged cultural resources studies at Acadia National Park and Saint Croix Island International Historical Site

Rebecca Cole-Will

National Park Service, Acadia National Park, Bar Harbor, ME

While Acadia National Park and the smaller unit of Saint Croix Island IHS are surrounded by and part of the maritime zone, both parks are land-based, with only limited jurisdiction in the intertidal zone. However, both parks protect and manage maritime resources and the potential for significant submerged resources (SR) is great. These resources have largely been unknown until recent research to inventory and assess them. There is some urgency to understand these resources. Predicted climate change effects such as sea level rise and changes in intensity and frequency of severe storm events potentially will impact coastal and submerged cultural resources at Acadia and Saint Croix. Two recent projects were completed at ACAD and SACR to begin to evaluate SR and will be highlighted in this poster presentation.

Establishing the uniqueness, conservation value and ecophysiological basis for maritime ‘pine-island’ vegetation communities

Michael E. Day and Amanda L. Butak

School of Forest Resources, University of Maine, Orono, ME

Bedrock outcrops along the eastern Gulf of Maine contain ‘vegetation islands’ inhabited by ericaceous shrubs, grasses and forbs. The most successful of these vegetation islands incorporate one of two pine species, pitch pine (*Pinus rigida*) or jack pine (*Pinus banksiana*). Our preliminary investigation suggests that ‘pine-island’ plant communities are less stressed by drought than their non-pine counterparts and have greater soil depths. Successful establishment of jack and pitch pines almost always occurs in fissures, suggesting that they are tapping water sources that are located well below the surface, and further suggesting that pine-island plant communities may be dependent on hydraulic lift as a water resource. Hydraulic lift occurs when deep-rooted species move groundwater from lower levels to surface soils, driven by lower water potentials in the upper soil strata compared to that within tree roots.

Pitch pine is the dominant pine-island species on sites west of Frenchman’s Bay, while jack pine occupies the same niche to the east. Our previous research suggests that this distribution does not result from cold tolerance, fecundity, germination success, or pollen viability. We are currently investigating species differences in carbon balance resulting from temperature differentials and atmospheric moisture stress levels as likely environmental variables resulting in this allopatric pattern. Geographic isolation and poor migration potential make pine-islands some of the most at-risk community types in a changing climate. The knowledge base we are developing will be critical for management decisions intended to maintain the presence these unique plant communities in Acadia National Park.

Using stable isotopes to identify population dynamics of bats at Acadia National Park, Maine

Timothy J. Divoll^{1,2}, Bruce Connery³, Bik Wheeler³, Robert H. Michener⁴, Karen B. Anderson³, Shaylyn K. Hatch², Dustin Meattley², and Cassandra Alston³

¹Biology Department, University of Southern Maine, Portland, ME

²BioDiversity Research Institute, Gorham, ME

³National Park Service, Acadia National Park, Bar Harbor, ME

⁴Biology Department, Boston University, Boston, MA

Bats in northeastern North America face anthropogenic challenges such as heavy metal contamination, habitat loss and degradation, white-nose syndrome, and wind power development. Little information is known about the natural history and coastal usage patterns of bat species in Maine, facilitating the need for baseline natural history data for these species. We used several methods—banding, acoustic recording, and stable isotope

sampling—to better understand spatial and temporal bat activity along the coast of Maine and monitor variance in the population at Acadia National Park. In 2009, 2010 and 2011, we captured and banded 1037 bats, sampled 256 for stable isotopes, and recaptured 22. We passively recorded echolocation calls in 2010 from April 4th to October 13th at two distinct high activity sites. Though only some stable isotope and no acoustic recording data have been analyzed, capture data reveal a substantial population of little brown (*Myotis lucifugus*, n=607), northern long-eared (*Myotis septentrionalis*, n=273), and eastern small-footed (*Myotis leibii*, n=137) bats at this coastal refuge. Temporally, little brown and eastern small-footed bats shared an inverse relationship: *Myotis leibii* dominated the percentage of capture in April, declined mid-season, and picked up again in September whereas *Myotis lucifugus* dominated in June, July and August. *Myotis septentrionalis* maintained a stable representation through capture efforts from April to September. Our data provides a natural history baseline for a population of bats at one geographic location, indicating further need for quantitative studies on specific issues in similar bat populations. Acadia National Park may be at the convergence of many age-old coastal movements and migrations, thus a stronghold for these *Myotinae* species—which have all recently been petitioned for listing under the Endangered Species Act.

Friends of Taunton Bay

Frank C. Dorsey

Friends of Taunton Bay, Hancock, ME

Friends of Taunton Bay (FTB) is a volunteer, non-profit organization in Hancock County, Maine with the mission to: “*Understand and promote the health and integrity of the Taunton Bay ecosystem.*” The poster will present characteristics of the bay and some of FTB’s research and education activities.

The Suffering of Women in Mount Desert

Tim Garrity

Mount Desert Island Historical Society, Mount Desert, ME

In the common memory of the American Civil War, the theme of male hardship is so prominent as to overshadow the experience of women. Though the story of women’s experience has been largely eclipsed, historical records show that women’s lives were very hard during the three middle decades of the nineteenth century (1850-1879), and the Civil War made those lives even harder. Both the preeminence of men in the Civil War memory and the suffering of women can be found in the history of Mount Desert, Maine.

During the middle decades of the nineteenth century, the annual number of deaths of women age seventeen to forty-five was so high, that men seldom died in greater numbers except during the four years of the Civil War. During this period, almost twelve women

of childbearing years died for every ten men of military age. The Civil War imposed upon women the additional burdens of poverty, widowhood, responsibility for the work of absent men, and the care of orphans. The hardships of life fell upon distinct populations of males and females, each operating within sharply circumscribed social worlds, as defined by the most powerful cultural forces of society: religion, family, work, literature and education. But local records show abundant evidence that cracks were forming and widening in some of the foundational assumptions about the proper roles of males and females.

Site-specific integrated pest management of the invasive European fire ant, *Myrmica rubra* L. (Hymenoptera: Formicidae), within Acadia National Park.

E. Groden, K. Bernard, and J. Lund

School of Biology and Ecology, University of Maine, Orono, ME

The European fire ant is a serious invasive pest that is threatening native fauna and plant health in many areas of Acadia National Park, as well as interfering with visitor use of park facilities. Due to the variable nature of infestations and park geography, site specific integrated management plans were designed and implemented for six sites over the 2011 field season with the goal of reducing populations of ants, and where possible, eradicating the ant. Multiple pesticide products were deployed, as well as repellents, using both broadcast and bait station methods for dissemination. Ant population densities were mapped at each site before and after each treatment so that the efficacy of each strategy could be assessed, and hotspots (resurgence and/or recolonization) could be identified. Follow-up applications targeted portions of sites where infestations persisted. A decline in *M. rubra* density was evident at all sites. At the end of the season, the ants were observed to have been eradicated from one of the sites. This research suggests that site-specific plans can be effective means for managing this ant and eradication of small, isolated infestations in the park is possible.

Evaluation of a strategy for enhancing natural mortality of European fire ants, *Myrmica rubra*

E. Groden and J. Lund

School of Biology and Ecology, University of Maine, Orono, ME

A strategy for augmenting and enhancing the activity of an endemic natural enemy of the European fire ant (*Myrmica rubra*) was evaluated at two heavily infested sites in Acadia National Park (ANP) on Mount Desert Island and two privately owned property in Wayne and Orono, ME, in 2010. The insect mycopathogen, *Beauveria bassiana*, has been regularly recovered in dead *M. rubra* workers collected in ant colony middens in ANP over the past eight years. Applications of high inoculum of this pathogen have been

successful for management of other insect pests. We evaluated whether we could draw *M. rubra* workers to bait stations placed in the center of 1-m diameter areas that were inoculated with a high concentration of *B. bassiana* conidia (the infective stage of the pathogen), and whether the ants would carry the pathogen back to their colonies and initiate disease outbreaks. In mid June, commercially formulated conidia (Mycotrol®) were sprayed on the soil surface surrounding AntPro®, Liquid Bait Stations that were baited with a 25% v/v sucrose solution. Twelve to 20 bait stations and treated areas were deployed per site. Follow up sampling of ant colonies and ant activity was conducted throughout the summer. Although ant colonies collected from the study sites did not show higher rates of mortality compared with adjacent untreated sites, we did detect a trend of lower ant activity in the areas where the inoculated bait station areas were deployed.

Habitat protection – A partnership in southern Maine

Robert Houston and Mao Lin

U.S. Fish and Wildlife Service, Gulf of Maine Coastal Program, Falmouth, ME

Through a partnership in Merrymeeting Bay/Lower Kennebec Estuary of Maine, thousands of acres of important habitat have been protected in perpetuity. The Gulf of Maine Coastal Program plays an integral part of this partnership by working with partners on habitat protection grant applications and management.

Maine seabird nesting islands

Robert Houston and Mao Lin

U.S. Fish and Wildlife Service, Gulf of Maine Coastal Program, Falmouth, ME

Seabird restoration is a priority along the Maine coast for many agencies and organizations. Gulf of Maine Coastal Program participates in this partnership effort by working on habitat protection and restoration and by providing logistical and technical GIS support.

The Visitor Use Management Program at Acadia

Charlie Jacobi

National Park Service, Acadia National Park, Bar Harbor, ME

This poster will briefly summarize the activities of the Visitor Use Management Program at Acadia since 1994. Included are university and park-initiated research projects, visitor impact inventories, visitor experience monitoring, visitor education, and other mitigation programs.

Leave the rocks for the next glacier: Using signs to reduce visitor-built cairns at Acadia National Park

Charlie Jacobi¹, Jeff Marion^{2,3}, Brian Malone⁴

¹National Park Service, Acadia National Park, Bar Harbor, ME

²U.S. Geological Survey, Patuxent Wildlife Research Center, Virginia Tech Field Station, Blacksburg, VA

³Department of Forest Resources and Environmental Conservation, Virginia Tech, Blacksburg, VA

Visitors to Acadia National Park constantly tamper with the rock cairns that mark hiking trails in areas where there are no trees. We performed an experiment in 2002 with and without signs (n=3) on a one mile section of the South Ridge Trail of Cadillac Mountain using the simple four or six-stone Bates cairn for which it is easy to note any alterations. By far the most common cairn alteration was adding rocks followed by removal of the pointer rock. The average percent of intact cairns increased from 64% (n=43) to 81% (n=54) with the addition of signs. The average percent of cairns with added rocks decreased from 31% (n=21) to 12% (n=8). Each of these changes was statistically significant at the .05 level.

Although the reduction in cairn alteration was statistically significant, was it enough to warrant keeping three signs out along the trail? Would park managers be willing to install more signs throughout the trail system to combat this problem? Maintaining cairns every five days, even Bates cairns, is probably unsustainable. How frequently can these cairns be maintained? How much effort should we expend to mitigate this one problem? These are difficult questions. Another question is how much impact can Acadia National Park have in changing the behavior of visitors without the support of other natural areas emphasizing Leave No Trace principles, especially *Leave What You Find*. How much can a national Leave No Trace education program help with an acute issue in a park or forest? When, if ever, will the Leave No Trace ethic permeate the broader world of outdoor enthusiasts enough to help make a difference for trail-marking cairns at Acadia?

GIS modeling and iterative mapping techniques help Downeast towns comply with shoreland zoning laws

Tora Johnson

University of Maine at Machias, Machias, ME

In 2006, the State of Maine revised its 25 year-old shoreland zoning and resource protection laws. Amid confusion over where and how the new rules would apply, state officials released incorrect map layers showing vast stretches of coastline that would ostensibly be unbuildable under one of the new statutes. This touched off a firestorm of protest, particularly among landowners and developers in Downeast Maine. Release of corrected maps and clarification of the rules helped allay fears, but local officials and landowners remained skeptical as compliance deadlines approached. The statutes are exceedingly complex, making it difficult for towns with limited planning and mapping capacity to create compliant maps and ordinances. The Washington County Council of Governments and the GIS Service Center at the University of Maine at Machias collaborated to develop GIS models, cartographic templates, and other techniques to help Downeast towns develop the maps and ordinances required under the law. The use of GIS modeling allowed us to iteratively refine methods to adhere to state requirements and quickly produce maps for 39 towns. University and COG staff served as liaisons between state and municipal officials, minimizing further conflict and fostering trust. Participating towns avoided state-imposed ordinances, receive finer-scale zoning maps, and are able to refine inaccurate GIS layers. Further studies are using agent-based models to elucidate the causes of conflict over shoreland zoning and assess the efficiency and effectiveness of the law.

What Acadia National Park is doing to preserve our night sky

Christine M. Kercell^{1,2} and Karen Anderson¹

¹National Park Service, Acadia National Park, Bar Harbor, ME

²Slippery Rock University, Slippery Rock, PA

In 2009, the NPS received a grant from the National Park Foundation to assess the outdoor lighting and complete a night sky protection demonstration project at Acadia National Park as part of the requirements for being designated a “Dark-Sky Park” by the International Dark-Sky Association (IDA). One of the criteria for IDA designation is that two thirds (66%) of the park’s own outdoor lighting should be dark-sky compliant. In order to determine Acadia’s current state of compliance, an inventory of all outdoor light fixtures in the park was completed between May and August of 2011. A total of 829 outdoor lighting fixtures were inventoried. Of these, 340 meet the IDA’s compliant lighting standards, making the park’s lighting currently 41% compliant. The recent renovations of the Schoodic Education and Research Center campus account for 53% of the park’s overall compliance. Twenty-five (25) fixtures were observed to be broken or

not in use; simply removing these fixtures would bring compliance up to 42%.

Photographs, maps, and information about each fixture were compiled in a comprehensive inventory report which will be useful to park staff in planning, maintenance, and resource management as Acadia NP continues to move toward dark night sky compliance.

Shallow crustal bimodal plutonism during Acadian orogenesis: evidence about the ancient margin of North America from the Schoodic Peninsula

G. Christopher Koteas and Sheila J. Seaman

Department of Geosciences, University of Massachusetts, Amherst, MA

Eastern coastal Maine is characterized by many unique exposures of granitoids that preserve evidence of magmatism along the ancient margin of North America. Bimodal plutons, magma systems that have been constructed by repeated injections of mafic (dark-colored) and felsic (light-colored) magma have been studied throughout Maine. The Gouldsboro pluton is Silurian age (~450-410 million years ago) and is exposed from bottom (northeast) to top (southwest) on the Schoodic Peninsula. The Gouldsboro pluton can be divided into 4 major units based on both compositional and textural features. The Gouldsboro pluton intrudes the Cambro-Ordovician (~540-450 Ma) Bar Harbor Formation (Metzger, 1979; Gates, 1989) on its western margin and the Cambrian Flanders Bay greenstone (Gilman and Lash, 1988; Arnost et al., 2008) on its northwestern margin. The Gouldsboro pluton is intruded on its northern margin by the Tunk Lake pluton.

The Gouldsboro pluton preserves a complex intra-plutonic geometry. The plutonic stratigraphy is interrupted by near-vertical and sub-horizontal mafic dikes and sills. These disruptions are preserved as chaotic zones of enclaves adjacent to mafic dikes and sub-horizontal sheets. More subtle zones of mechanical mingling are also preserved in the center of the pluton where later pulses of felsic magma invaded the sheet-like geometry of the pluton. Evidence from the Gouldsboro pluton suggests variable degrees of communication between mafic and felsic magma injections. This led to a complex amalgam of separate magma inputs and allowed for magma mingling. The resulting geometry of the pluton is a potential proxy for shallow-crustal magma chamber in modern orogens.

Pollinating insects of the U.S. Fish and Wildlife Service Northeast Region

Sandra Lary

U.S. Fish and Wildlife Service, Gulf of Maine Coastal Program, Falmouth, ME

Pollinators play an important role in restoring and protecting USFWS trust resource species. Biologists can incorporate pollinator habitat needs into our daily work. For the USFWS Northeast Region, we highlight USFWS pollinator projects, describe habitat and species impacts, and provide an overview of the two bumblebee species that are currently in decline.

Fish passage and habitat

Sandra Lary, Jed Wright, Mao Lin

U.S. Fish and Wildlife Service, Gulf of Maine Coastal Program, Falmouth, ME

Maine's native diadromous fish rely on rivers and streams as migratory pathways to spawning, feeding, and nursing waters during distinct phases of their complex life cycles. Gulf of Maine Coastal Program works on many fish passage restoration projects throughout the Gulf of Maine.

The Acadian Internship in regional conservation and stewardship

Rob Lilieholm¹, Megan Gahl², Jim Levitt³, and Sarah Nelson⁴

¹School of Forest Resources, University of Maine, Orono, ME

²Bates College, Lewiston, ME

³Program on Conservation Innovation, Harvard Forest, Harvard University, Belmont, ME

⁴Senator George J. Mitchell Center for Environmental and Watershed Research, University of Maine, Orono, ME

The inaugural Acadian Internship Program enrolled 11 undergraduate and graduate students from the U.S. and abroad during the summer of 2011. The Program combined formal coursework, offered for credit through the University of Maine's Summer University, with a four-week paid internship program hosted by local governments and NGOs across Downeast Maine. Coursework began at the Schoodic Education and Research Center (SERC) in Acadia National Park in July 2011. During the first week, 24 guest speakers provided foundational coursework in conservation theory, tools, and methods. A diverse set of faculty, local experts, and guest lecturers - plus field trips and case studies within the region - grounded students in the resources and challenges within the study area. During the next four weeks, Interns worked in pairs with the Downeast Salmon Federation, the Open Space Institute, the Downeast Lakes Land Trust, and the

Washington County Council of Governments on projects ranging from community outreach and education, to forest operations and stream restoration. During the final week of the course, Interns reconvened at SERC to place what they learned in their field experience within the greater context of large landscape-scale conservation. The wrap-up included formal project reports and presentations open to all stakeholders. The Acadian Internship was sponsored by the Quebec Labrador Foundation, SERC, UMaine, the Frenchman Bay Conservancy and others. Plans are underway to offer the course again in 2012

Mercury bioaccumulation in wood frogs developing in seasonal pools

Cynthia S. Loftin¹, Aram J.K. Calhoun², Sarah J. Nelson³, Adria A. Elskus⁴, and Kevin Simon⁵

¹U.S. Geological Survey, Maine Cooperative Fish and Wildlife Research Unit, University of Maine, Orono, ME

²Department of Wildlife Ecology, University of Maine, Orono, ME

³Senator George J. Mitchell Center for Environmental and Watershed Research, University of Maine, Orono, ME

⁴USGS-BRD S.O. Conte Anadromous Fish Research Laboratory, Maine Field Office, University of Maine, Orono, ME

⁵School of Biology and Ecology, University of Maine, Orono, ME

Seasonal woodland pools contribute significant biomass to terrestrial ecosystems through production of pool-breeding amphibians. We documented total mercury (THg) in seasonal woodland pool water, sediment, litter and *Lithobates sylvaticus* LeConte (Wood Frogs) in Acadia National Park, Maine, USA. Total Hg concentrations in pool water varied over the study season, increasing during April-June and remaining high in 2 of 4 pools upon October refill. Pools surrounded by softwoods had lower pH, greater dissolved organic carbon, and greater THg concentrations than pools surrounded by hardwoods, with seasonal patterns in sediment but not litter. Total Hg increased rapidly from near or below detection in 1-2 week old embryos (<0.2 ng; 0-0.49 ppb wet weight) to 17.1-54.2 ppb in tadpoles within 6 weeks; 7.2-42.0 % of THg was methyl Hg in tadpoles near metamorphosis. Metamorphs emigrating from seasonal pools may transfer mercury into terrestrial food webs.

Parks and people: Managing outdoor recreation at Acadia National Park

Robert E. Manning

Park Studies Laboratory, Rubenstein School of Environment and Natural Resources, University of Vermont, Burlington, VT

With over two million annual visits on less than 50,000 acres, Acadia National Park may be the most intensively used national park in the U.S. This has raised concerns over the ultimate capacity of the park to accommodate recreational use without unacceptable impacts to park resources and the quality of the visitor experience. Over the past fifteen years, the park has commissioned a program of research to address this issue and support application of the National Park Service's Visitor Experience and Resource Protection framework. This program of research has been designed to 1) identify indicators and standards of quality for the visitor experience, 2) develop and test protocols to monitor indicators of quality, and 3) assess visitor support for management practices designed to maintain standards of quality. Research methods include visitor observation, qualitative and quantitative visitor surveys, visual simulations, tradeoff analysis, computer-based simulation modeling, resource inventories and assessments, remote sensing, and field experiments. This program of research has been applied throughout the park, including Mount Desert Island, the Schoodic Peninsula, and Isle au Haut. Findings from these studies have supported development of a series of principles to guide management of outdoor recreation at Acadia and other units of the national park system. A book describing this program of research at Acadia was recently published by the University Press of New England.

The critical leading edge of a Mt. Desert Island salt marsh – interface with freshwater wetlands

Margot Mansfield

University of Maine, Orono, ME

Salt marshes are dynamically important ecosystems for a myriad of reasons including: serving as nurseries; providing a buffer for coastal uplands by shielding and protecting against direct wave attack and storm surges; retaining fine-grained sediment delivered by rivers; and filtering nutrients and pollutants from runoff following storms, all of which thereby reduce impact on the environment. Since sea level exerts strong control over system dynamics in salt marshes, reading the stratigraphic record will allow stronger predictions of future changes at the edge of salt marsh (SM) and freshwater wetlands (FW). This research aims to determine the past behavior of the SM-FW transition zone in several marshes along the Down East coast of Maine (including Mt. Desert Island) in response to sea-level fluctuations, and predict how current and future trends of sea-level rise affect these sensitive ecosystems. Additionally, this research aims to determine the mechanisms driving change at the leading edge of the salt marsh transgression. An intensive field campaign was undertaken this past summer to collect ground-penetrating radar (GPR) data and several cores along planned transects. The GPR data yields general substrate stratigraphy and guided coring and sampling transects to establish overall stratigraphy and rates of change (sediment accumulation). Stratigraphic sections using cores and radiometric dating enable reconstruction of changes in SM-FW transition zones over the past several decades to centuries.

Insect and spider biodiversity on the Schoodic section of Acadia National Park

David Manski¹, Don Chandler², Charlene Donahue³, and Andrei Alyokhin⁴

¹National Park Service, Acadia National Park, Bar Harbor, ME

²University of New Hampshire, Durham, NH

³Maine Forest Service, Augusta, ME

⁴School of Biology and Ecology, University of Maine, Orono, ME

Between 2004-2011, annual surveys of terrestrial arthropods were conducted over a 24-hour period during each summer at the Schoodic section of Acadia National Park. These surveys were a product of collaboration between the National Park Service, Maine Forest Service, Maine Entomological Society, SERC Institute, and other academic and science institutions. Professional entomologists, amateur naturalists, and the public who participated in these surveys used a variety of techniques (nets, lights, traps) to sample insects and spiders. A total of 1,477 species were identified from collections made by participants, representing 235 families. Beetles and moths/butterflies represent 47% of all the identified species (353 and 344 species respectively). Voucher specimens of all species are housed in the Acadia National Park museum collection. This presentation summarizes details and results about these biodiversity discovery events.

Hidden risk: Mercury in terrestrial ecosystems of the Northeast

J. McKay, D. Evers, A. Jackson, J. Franklin, N. Schoch, E. Adams, I Johnson, D. Buck, and C. Osborne

Biodiversity Research Institute, Gorham, ME

Mercury deposition, a pervasive global hazard to ecosystem health, puts terrestrial invertivores at risk from mercury exposure. To date, the risk of mercury exposure in invertivores such as songbirds and bats has been largely ignored, favoring a focus on higher trophic level feeders such as piscivorous loons and bald eagles. Mercury contamination across terrestrial ecosystems poses a hidden risk to these endemic invertivores. Ingestion of invertebrates that feed on mercury contaminated detritus results in the bioaccumulation of mercury throughout invertivore blood and tissue, causing negative effects on health and reproduction. Biodiversity Research Institute (BRI) documented mercury in key invertivore species in five different ecosystem types throughout the Northeast. Through this regional effort, BRI established a template using key species as indicators of ecosystem health that can be used throughout Acadia National Park and across the National Park System. Understanding how mercury affects these species will direct management actions at local levels to reduce Hg exposure and provide direct benefit to wildlife populations.

Effects of mercury on male song in Nelson's sparrows (*Ammodramus nelsoni*)

Jennifer L. McKay^{1,2} and Christine R. Maher¹

¹Department of Biology, University of Southern Maine, Portland, ME

²Biodiversity Research Institute, Gorham, ME

Mercury (Hg) adversely affects the health and behavior of exposed wildlife; however, behavioral effects remain largely unknown. Changes in bird song may affect a male's fitness because song reveals male quality and thus influences female mate choice. Nelson's Sparrows (*Ammodramus nelsoni*) live exclusively on salt marshes and risk high levels of Hg exposure and bioaccumulation. We recorded songs of male Nelson's Sparrows at two Maine locations that differed in Hg levels to determine if Hg exposure related to song characteristics. Males from the two populations differed in blood mercury levels. Although high and low tonal frequency, tonal frequency range, and bout duration did not differ between populations, males with higher blood Hg levels produced shorter gap durations than males with lower blood Hg levels, indicating that males with higher Hg loads sang faster songs. Increased song rate suggests that Hg exposure affects some components of song. Perhaps reproductive behaviors, such as song production, can be used to indicate and evaluate the fitness costs of Hg exposure.

Larval recruitment of mussels, invasive ascidians and crabs on artificial collectors is generally higher along the western coast of Maine.

Douglas C. McNaught and Wendy S. Norden

University of Maine at Machias, Machias, ME

Along the coast of Maine, recruitment of most marine species follows a generalized regional pattern, with higher recruitment rates at western sites. Using artificial collectors we found that the invasive ascidians *Botryllus schlosseri*, *Botrylloides violaceus*, *Ciona intestinalis*, *Ascidella aspersa* and *Styela clava* were more abundant in the western (southwestern) sites than in the eastern (northeastern) sites. This general pattern also applies to a number of other recruiting species including native mussels, *Mytilus* spp., the invasive bryozoan, *Membranipora membranacea*, and the invasive crabs, *Carcinus maenas* and *Hemigrapsus sanguineus*. The colonial ascidians, *Botryllus* and *Botrylloides*, showed a preference for smooth surfaces over filamentous ones, and the mussels preferred the filamentous surfaces. While recruitment of many marine organisms can appear stochastic in space or time, there can be some consistent regional patterns. Higher recruitment in the western sites of Maine may be the result of greater oceanographic dispersal due to the westward flow of the Maine coastal current, higher seawater temperatures in the west, and more anthropogenic introductions having occurred in the western harbors.

Six years of forest health monitoring in Acadia National Park

Kate Miller¹, Jessie Wheeler¹, Brian Mitchell², and Geri Tierney³

¹National Park Service, Inventory and Monitoring Program, Northeast Temperate Network, Bar Harbor, ME

²National Park Service, Inventory and Monitoring Program, Northeast Temperate Network, Woodstock, VT

³SUNY College of Environmental Science and Forestry, Syracuse, NY

Background

Since 2006, the Northeast Temperate Inventory and Monitoring Network (NETN) has been monitoring forest health annually in Acadia National Park, and biennially in 9 National Historic Parks in New England, New York, and New Jersey. The monitoring program uses a protocol based on the USDA Forest Service's Forest Inventory and Analysis program, and relies primarily on an Ecological Integrity Scorecard to interpret forest condition to park managers. The Ecological Integrity Scorecard rates condition for a suite of metrics that address forest structure, composition and function. For each metric, assessment points were defined that distinguish acceptable or expected conditions from undesired conditions based on current scientific understanding of their natural or historic range of variation. Ecological Integrity is then interpreted using three categories for each metric: Good, Caution and Significant Concern. "Good" represents acceptable or expected conditions; "Caution" indicates a problem may exist; and "Significant Concern" indicates undesired conditions that may need management action.

Results/Conclusions

Ecological integrity metrics in Acadia NP indicate that forests are approaching mature stages of forest succession, but are lacking late successional structure such as large snags. Forests are largely un-invaded by invasive plant species and exotic earthworms, and appear to have adequate regeneration. Stressors that may be impacting forest health in Acadia NP include acid deposition and forest pests and diseases. Major threats to forest health in Acadia NP include introduction of forest pests such as emerald ash borer, Asian longhorned beetle, and hemlock woolly adelgid, stressors induced by climate change, and new invasions of exotic plants.

Stories from the water: The natural history of the Northeast Creek watershed

Hale Morrell

College of the Atlantic, Bar Harbor, ME

The Northeast Creek watershed on Mount Desert Island (MDI), Maine has been an important part of the Island's human and natural history. Historically people of MDI have used waterways within this watershed, such as Mill Brook and Northeast Creek, for transportation, economic infrastructure, social gatherings, and aesthetics. It is one of the

largest watersheds on MDI and a significant portion of the watershed is within or abuts Acadia National Park. The history of this watershed has influenced the ecology and history of Acadia National Park. This poster explores the role of Mill Brook and Northeast Creek in the human and natural history of MDI and shares some of the stories of people who lived and worked with these waterways.

Sensible sentinels: Preliminary mercury data for dragonfly nymphs (*Odonata: anisoptera*) across northern New England corroborate expected spatial pattern

Sarah J. Nelson¹, Celia Chen², Hannah Roebuck², Bill Zoellick³, Ed Lindsey⁴, Emily Sherman⁵, Jennifer Stainton⁶, and Erica Ferland⁷

¹ Senator George J. Mitchell Center for Environmental and Watershed Research, University of Maine, Orono, ME

² Dartmouth College, Hanover, NH

³ Schoodic Education and Research Center Institute, Winter Harbor, ME

⁴ Old Town High School, ME

⁵ Scarborough High School, ME

⁶ Woodstock Union High School, VT

⁷ Stevens High School, NH

Mercury (Hg) is a potent neurotoxin that is delivered to ecosystems via deposition from a global atmospheric pool, and ultimately bioaccumulates in aquatic and terrestrial foodwebs. All Maine (ME), Vermont (VT), and New Hampshire (NH) surface waters are under fish consumption advisory and are considered impaired with respect to Hg because of the difficulty in predicting which systems are most affected. Together with a team of citizen scientists, we are evaluating the utility of dragonfly nymphs (*Odonata: Anisoptera*) as sentinels for Hg in the Gulf of Maine region. The average Hg concentration in dragonfly nymphs sampled across ME, NH, and VT was 53 ± 47 ppb (mean $\pm$ SD, wet weight basis, $n=199$), with $\sim 20\%$ of individuals having concentrations greater than the proposed Hg wildlife safety criterion (77 ppb). Across the region, we used our data to address hypotheses regarding whether Hg varied with body size or by family; these characteristics were less important than a field site's landscape setting. Data from a survey of a variety of surface water sites in or near three National Park/National Wildlife areas in ME (Acadia, Sunkhaze), and VT (Marsh Billings Rockefeller) and other sites confirmed that Hg in dragonfly nymphs was more variable among sites than within a site, suggesting that they are useful indicators for Hg. Hg in dragonfly nymphs appears to be associated with dissolved organic carbon, a proposed predictor for Hg methylation. More research on dragonfly larval life history will help to develop a mechanistic understanding of this spatial variability in Hg bioaccumulation.

Using LiDAR data to map future projected sea level near salt marshes at Acadia National Park, Maine

Martha Nielsen and Robert Dudley

U. S. Geological Survey, Maine Water Science Center, Augusta, ME

Coastal wetlands, particularly salt marshes, are important ecosystems that provide many important ecological functions in the Gulf of Maine. The USGS is investigating salt marshes in and around Acadia National Park with the goal of determining which salt marshes may be threatened by sea-level rise and which salt marshes may be able to adapt by migrating into adjacent low-lying lands, using recently collected LiDAR elevation data for the coast of Maine. One hundred marsh elevation points surveyed using high-accuracy Global Positioning System equipment are being used as a check against the LiDAR-derived elevations. The USGS has worked with the National Park Service and conservation partners such as the Maine Coast Heritage Trust to select salt marshes used for the LiDAR data accuracy assessment. A detailed map of salt marshes in the study area will be overlain onto the LiDAR-derived land surface. Using this land-surface dataset, we will identify low-lying areas adjacent to existing salt marshes that could be expected to flood as a result of a 600-mm (2.0 ft) rise in sea level and that could be suitable for salt marsh habitat (that is, not developed). The USGS also will identify any potential physical barriers (roads, berms, and bridges) to inland migration of salt marshes. The results of our independent accuracy assessment of the LiDAR data will be used to estimate 95-percent confidence intervals for the prediction of areas with a potential to flood and possibly form new salt marsh.

Place-based science: Educational field trips

Cynthia Ocel, Michael Marion, Jessica Fefer, and Melanie Klein

National Park Service, Acadia National Park, Bar Harbor, ME

Acadia National Park provides opportunities for understanding the natural world and inspires individual stewardship in the younger generation. Having youth actively engaged in the learning process is vital for success in our resource management and protection efforts. This can be accomplished through several means including field-based programs, citizen science, service learning, and seasonal employment. These activities provide opportunities for students to understand, appreciate and participate in preserving our natural and cultural heritage.

Sea-run brook trout research in Stanley Brook, Acadia National Park

Matthew O'Donnell¹, Bruce Connery², Benjamin Letcher¹, Joseph Zydlewski³, Andrew Whiteley⁴, Douglas Sigourney¹ and Todd Dubreuil¹

¹U. S. Geological Survey, Conte Anadromous Fish Research Center, Turners Falls, MA

² National Park Service, Acadia National Park, Bar Harbor, ME

³ U. S. Geological Survey, Maine Cooperative Fish and Wildlife Research Unit, University of Maine, Orono, ME

⁴Department of Environmental Conservation, University of Massachusetts, Amherst, MA

Small streams on the northeast Atlantic coast historically have represented important habitat for sea-run brook trout (*Salvelinus fontinalis*). Specifically in Maine, historic records indicate that streams on Mount Desert Island (MDI) (e.g. numerous streams in Acadia National Park) had contained significant sea-run brook trout populations. In spite of being sought after by anglers, the current status and presence (or absence) of anadromous populations are largely unknown for most Maine waters. Additionally, there is a troubling lack of management programs currently in place that can evaluate and track the status of anadromous brook trout or to recommend management actions (i.e., adjusting harvesting levels and seasons, habitat protection and restoration, collaborative research and monitoring, etc.). Such information is needed to assure conservation of this life history form and the coastal fresh and marine systems on which it depends.

In an effort to unravel some of the mysteries surrounding sea-run brook trout life history, we began studying brook trout in Stanley Brook, Bar Harbor, ME. Since 2006, our approach has been to conduct electrofishing surveys twice a year to collect brook trout over a 2km stretch of brook and to surgically implant each brook trout with a Passive Integrated Transponder (PIT tag) which allows us follow that fishes growth, survival and movement pattern over time. Additionally, a fin clip is taken from each PIT tagged for DNA analysis; from which we will construct a pedigree for brook trout in Stanley Brook. Completed analyses indicate that 1) brook trout from Stanley Brook enter the marine environment primarily in the spring and fall 2) fish that enter the marine environment display higher growth rates than freshwater residents and 3) fish move long distances (at least 2km) to utilize the marine environment.

Understanding a continental-scale behavior in an era of climate change

Brian J. Olsen and Jennifer D. McCabe

University of Maine, Orono, ME

Climate change has the potential to disrupt not only animal breeding and annual survival but also the success of large-scale migratory behaviors. In fact, migratory species are likely at higher risk of impact from climate change than non-migratory species because of the diverse ecosystems through which they pass. For many of these species, migration represents a critical period in the annual cycle, during which individuals endure the

majority of their annual mortality risk. The ability to migrate successfully during an era of climate change is therefore critical to the long-term viability of these species. Our understanding of how animals use landscapes on both a small and large scale will be critical to our ability to identify management needs and predict future impacts on the value of our federal lands for migratory species. During the fall of 2010, we began to categorize the movement of migratory birds, bats, and insects across the Gulf of Maine as a function of weather, habitat characteristics, and distance from the mainland in the greater Acadia region. The end result of this project will be the development of a predictive model of animal movement under a variety of climate change scenarios. Initial results emphasize the importance of island habitats for a variety of species, including birds of prey, and the importance of shrub habitats on the mainland for a host of songbirds.

Flotsam on Great Duck Island

Robin Owings

College of the Atlantic, Bar Harbor, ME

1500 Lobster buoys were photo-documented and collected on Great Duck Island, south of Acadia National Park, between the dates of June 19th and August 4th 2011. Data was collected from these buoys regarding location, section, catalogue number, photo identification number, collection date, buoy identification number, physical description, and material. Buoys were color-coded according to paint type, and organized in a spreadsheet database according to catalogue number. Using the identification numbers provided on each buoy, these 1500 are currently being traced to their original owners using the Lobster License-holders 2010 database provided by the Maine Office of Licensing and Registration in Augusta, ME. This information can potentially provide information regarding ocean current patterns around Mount Desert Island which carry flotsam to Great Duck. Better knowledge of debris transport could assist in the planning of resources to environmental disasters such as oil spills.

Mushrooms of the Acadia National Park area

David Porter with Lauren Benzaquen, Katie Jumper, Will Batt, Ben Byrne, Jillian Gall, Hunter McAdam, Matt McElwee, Margaret Stern, and Stuart Weymouth

College of the Atlantic, Bar Harbor, ME

Mushrooms are the macroscopic fruiting bodies of what are commonly called macrofungi. Most macrofungi are Basidiomycetes and Ascomycetes. Their biodiversity is assessed in the environment by the appearance of mushrooms. But because of the often evanescent nature of mushrooms, in recent years environmental DNA techniques has been demonstrated to be a more accurate way to assess fungal diversity. Nevertheless,

mushroom observation and documentation remains an accessible technique for field classes in natural history. Although the relatively undisturbed mixed hardwood/conifer forests of MDI and vicinity is a rich source of diverse mushrooms, few extensive assessments of mushrooms in the vicinity of Acadia NP have been carried out. The most comprehensive was an unpublished study from 1975 to 1981 by Walter Litten who documented more than 300 species of mushrooms in the Bar Harbor vicinity. The two day Acadia NP Macrofungal Bioblitz in September of 2009 discovered 90 species during a relatively dry spell. As part of the Mycology class this fall (2011) at College of the Atlantic, we are collecting, documenting and preserving mushrooms found on MDI. The range of diverse forms and taxa are depicted in the accompanying photographs and illustrations.

Changing landscapes, changing climates, and the changing needs of Acadia's tidal marsh dependent birds

Meghan Powell

Antioch University New England, Keene, NH

The ecosystem services provided by coastal marshes for humans and wildlife is widely recognized (Boorman 1999), but these habitats are under constant threat of disappearing completely due to landscape development and sea-level rise. Understanding how marsh bird communities have changed over the past several decades will help assess changes in overall ecosystem health.

The marshes of Acadia National Park (ANP) face the threats of sea-level rise, climate change, and increased human development. To predict the future impact of these threats on the salt and tidal marshes of Acadia, we need to understand: A) how the tidal marsh bird community has responded to recent changes in watershed development and sea-level rise and B) how current watershed uses affect avian populations. Past studies were completed in 1999, 2001 and 2002 to determine the presence and abundance of avian species in the tidal marshes of Mount Desert Island. The purpose of this proposed study is to compare the present bird community of four tidal marshes in the greater Acadia region with these historical surveys and determine: A) whether sea-level rise has caused changes and B) how upland land use and development can affect the sensitivity of bird communities to climate change and C) which of these pose the greatest threats to these marshes. I conducted point counts, counting all birds seen and heard. To reveal how the marshes in the watersheds have changed over the past decade a comparison of past aerial photographs will be made using GIS (Geographical Information System).

Uncovering, collecting, and analyzing records to investigate the ecological impacts of climate change: From Concord to Acadia

Richard B. Primack¹, Caitlin McDonough^{1,3}, Glen Mittelhauser², and Abraham J. Miller-Rushing³

¹Department of Biology, Boston University, Boston, MA

²Maine Natural History Observatory, Gouldsboro, ME

³National Park Service, Acadia National Park and Schoodic Education and Research Center, Bar Harbor, ME

Historical records are an important resource for understanding the biological impacts of climate change and long term changes in plant and animal communities. Such records include naturalists' journals, club and field station records, museum specimens, photographs, and scientific research. Finding records and overcoming their limitations represent serious challenges to managing biological diversity and is increasingly relevant to climate change research. Here we describe efforts to locate data from Concord, and other areas of eastern Massachusetts, providing a template that can potentially be replicated at Acadia National Park and nearby areas. Analyses of diverse data sources, including observations made in the 1850s by Henry David Thoreau, indicate that climate change is affecting the phenology, presence, and abundance of plant and bird species in Concord. This approach is already being used to examine how plant species have changed in abundance at Mount Desert Island over the past 100 years.

Despite recent work on historical records, many sources of historical data are underutilized or even undiscovered. Analyses of these data may provide insights into how a changing environment, and in particular climate change, are affecting the plants and animals of Acadia National Park. This work may also suggest techniques to manage threats to rare, endangered and declining plants and animals. . Moreover, the results can be useful for communicating local examples of changing environmental and climatic conditions to the public.

Soil drainage and forest type influences on soil organic carbon fractions in a New England forested watershed

Jay Raymond¹, Ivan Fernandez¹, Tsutomu Ohno¹, Kevin Simon²

¹Department of Plant, Soil and Environmental Sciences, University of Maine, Orono, ME

²School of Biology and Ecology, University of Maine, Orono, ME

Soil organic carbon (SOC) fractions vary across forested watersheds among distinct soil drainage classes and vegetative communities. Defining the continuum between labile and recalcitrant SOC in these systems is important for our understanding of biogeochemical cycling processes influencing carbon (C) and ecosystem health. We conducted a plot scale field study across three different mineral soil drainage classes (moderately well drained – MWD; somewhat poorly drained – SWPD; poorly drained - PD) and in two

dominant forest types (coniferous, broad-leaved deciduous) in a temperate forested watershed in eastern Maine. Soil respiration (SR), soil temperature (Ts), and gravimetric soil moisture (SM) were measured as a monthly time series from June through November 2010. Samples were simultaneously collected from the O and uppermost 5 cm of the mineral soil and analyzed for hot water extractable carbon (HWE) to track temporal patterns of labile solid phase soil C. In addition, SOC fractionation was conducted to determine operationally defined labile, stable and recalcitrant SOC fractions from various depths in adjacent quantitative pits in each plot. Seasonal trends were evident in SR, Ts, SM, and HWE. Maximum values for SR and Ts were observed during July and August 2010, while maximum values for SM were observed in early June and late fall. SWPD soils had a 31% and 7% higher mean SR compared to MWD and PD soils, respectively. The deciduous forest type had higher mean SR compared to the coniferous forest type in MWD and SWPD soils, with the trend reversing in PD soils. Evidence from this study suggests SWPD soils play an important role in landscape resilience to drought stress during the growing season.

Phenology at the Bear Brook Watershed in Maine: Foliar chemistry and morphology

Erin Redding¹, Ivan Fernandez¹, Michael Day², G. Bruce Wiersma²

¹Department of Plant, Soil and Environmental Sciences, University of Maine, Orono, ME

²School of Forest Resources, University of Maine, Orono, ME

Annual developmental events in biological systems are dependent, in part, on environmental conditions. They are valuable bio-indicators of shifting climate, making the science of phenology an essential component of climate change research. Many studies have been done on the effects of temperature and photoperiod on phenophases, but fewer have explored the consequences of nutrient availability in terrestrial ecosystems. The Bear Brook Watershed in Maine (BBWM) provides an opportunity to evaluate morphological and chemical phenology as influenced by decadal-scale experimental ecosystem acidification and nitrogen (N) enrichment. BBWM is a paired watershed study designed to assess responses to a changing chemical and physical climate. The West Bear (WB) watershed has been treated bimonthly with (NH₄)₂SO₄ since 1989; the East Bear (EB) watershed serves as a reference. Significant differences have been found between the WB watershed and the EB watershed with respect to biogeochemical cycles affecting essential plant nutrients.

Phenophases of *Acer rubrum*, *Acer saccharum*, and *Picea rubens* in both watersheds were observed throughout the 2010 growing season. Phenological development phases included bud burst, flowering (*A. rubrum*), leaf or needle emergence and unfolding, leaf senescence (*Acer* spp.), and leaf fall (*Acer* spp.). Clear species-specific phenological patterns were observed, but no treatment effects were evident, possibly as a result of the limited precision of this initial study. Chemical phenology of canopy tree foliage was also examined. Foliage samples were collected on a monthly basis from May through October 2010 and analyzed for total N, carbon (C), phosphorus

(P), calcium (Ca), magnesium (Mg), potassium (K), aluminum (Al), boron (B), copper (Cu), iron (Fe), and manganese (Mn) content. Nitrogen was the only element that was significantly higher in the WB watershed for all species, although not all months showed significant differences. West Bear *A. rubrum* foliar N concentrations were only higher in May, while WB *A. saccharum* and *P. rubens* foliar N concentrations were consistently higher than EB. Foliar C, P, Mn, and Fe concentrations in *A. rubrum* trees and foliar Fe concentration in *A. saccharum* trees were higher in the WB watershed. Foliar P concentrations were higher in one year old *P. rubens* foliage of the WB watershed compared to EB. Foliar Ca and Mg concentrations were lower in *A. rubrum* of the WB watershed, but did not differ between treatments in *A. saccharum* or *P. rubens*. Foliar Cu and Zn concentrations were lower only in *A. saccharum* trees of the WB watershed. Foliar K and Al concentrations did not differ between treatments in any species. Foliar N and P concentrations decreased in all species throughout the growing season, while foliar Ca, K, and Al concentrations increased or were constant.

This study found clear species-specific patterns of morphological and chemical phenology with time, but did not show evidence for visible alterations in seasonal development as a result of ecosystem acidification and N enrichment. Chemical phenology, as applied here, showed some responses consistent with ecosystem change that should be further explored for application to coupled chemical-biological indicators of a changing chemical and physical climate.

“Red tide” and eastern Maine

Alexandra Rohrer and Nathan Kaufmann

Department of Marine Resources, Lamoine, ME

Red tide or Harmful Algal Blooms (HABs) are a regular occurrence in Maine. The most common HAB is caused by the dinoflagellate *Alexandrium* and it is the source of the neurotoxin, saxitoxin, the toxin which produces paralytic shellfish poisoning (PSP). PSP becomes a human health hazard during blooms of *Alexandrium*, when it is consumed and the toxin accumulates in bivalves such as mussels, clams, oysters and scallops. Once *Alexandrium* cells are digested, the toxin remains behind and continues to accumulate if more *Alexandrium* is ingested. Saxitoxin is then transferred through the food web when other species, including humans eat the toxic shellfish.

Due to the potential hazard of PSP in Maine, the Department of Marine Resources monitors bivalves along the coast for this toxin regularly, beginning early spring and continuing through October or later if necessary. Once toxin levels reach quarantine limits, the state closes flats, shores and waters to the harvest of specific shellfish species. As different species concentrate the toxin at different rates, by testing multiple species the department can create surgical, species specific closures. This ensures that public health is protected while creating as minimal an impact as possible on the shellfishing economy.

Fractal analysis and thermal-elastic modeling of a subvolcanic magmatic breccia, the Shatter Zone, Mount Desert Island, Maine

Samuel G. Roy¹, Scott E. Johnson¹, Zhihe Jin², and Peter O. Koons¹

¹Department of Earth Sciences, University of Maine, Orono, ME

²Department of Mechanical Engineering, University of Maine, Orono, ME

The Shatter Zone of Mount Desert Island, Maine, is a 450-1000m thick magmatic breccia that defines the eastern perimeter of the shallowly-emplaced (<5km) Cadillac Mountain Intrusive Complex. The Shatter Zone formed during a large volcanic eruption, possibly triggered by emplacement of mafic magma into the existing felsic chamber, resulting in fragmentation of the metasedimentary and diabase wall rock and entrainment of the resulting clasts in ~900°C granitic magma. The degree of brecciation grades from clast-supported breccias at the outer margin of the Shatter Zone to isolated clasts supported by the granitic matrix. Field observations point to an explosive breccia mechanism, and clast size distribution analysis yields fractal dimensions ($D_s > 3$) that agree with those known to result from explosion ($D_s > 2.5$). Field observations, clast circularity data, and clast boundary shape data suggest that the clast sizes and shapes reflect post-brecciation modification by partial melting and thermal fracture. Numerical modeling is employed to explore the possible thermal-mechanical effects on the size distribution of clasts. Instantaneous immersion is assumed for metasedimentary clasts (650°C) in a hot granitic matrix (800°C-900°C) for different matrix volume percentages. Thermal analysis is restricted to conductive heat transfer corrected for latent heat. Metasedimentary clast melt was an effective secondary modification processes which markedly altered clast size distribution for clast populations adjacent to the intrusive body. Diabase clasts experienced late-stage fracture due to the instantaneous thermal pulse with a preference to fracture angular clasts with high surface area to volume ratios.

Biogeography of aquatic microbial communities in Acadia National Park and Mt. Desert Island

Parke A. Rublee¹, Verrico Boyd¹, and William G. Gawley²

¹University of North Carolina at Greensboro, Greensboro, NC

²Acadia National Park, Bar Harbor, ME

This study is designed to assess the biogeography of microbial communities at relatively small scales (~ 10 – 15 km) but across several physical and chemical gradients that are represented on Mount Desert Island. Twenty lakes and ponds were chosen for routine sampling during summer 2011 based on previous water quality studies by the National Park Service (Gawley, et al. 2007) that showed a clear eutrophication gradient as determined by mean secchi depth (Figures 1, 2). Several additional lakes were also sampled at less frequent intervals (Figure 2). Overall these lakes represent gradients of size (surface area, depth) elevation, and relative use by humans, in addition to the nutrient

gradient represented by trophic status. Further, the lakes and ponds are located in several adjacent watersheds, generally separated by mountains that run in a north-south direction, and that are predominantly influenced by wind running oriented in the same directions as the watershed.

Population-level biological responses to the Atlantic Multidecadal Oscillation in Gulf of Maine Atlantic herring (*Clupea harengus*): Potential climatic forcing of whole, somatic and ovary weight-at-age decline

Adam T. St. Gelais, James R. Becker, and Matthew D. Cieri

Maine Department of Marine Resources, Bureau of Resource Management, West Boothbay Harbor, ME

Recent studies have highlighted the potential importance and impact of long-term, low-frequency oceanographic oscillations such as the Atlantic Multidecadal Oscillation (AMO) on the population ecology of commercially important marine species. Ecological effects of the AMO are seen at the level of primary production and, assuming linked impacts on secondary production (decreased biomass, trophic composition of zooplankton) AMO influences should be detectable in high biomass, schooling planktivorous fish species like Atlantic Herring (*Clupea harengus*). A 60 year continuous data set provided by the Maine Department of Marine Resources was analyzed from 1970-2010 for long term biological trends in Gulf of Maine *C. harengus* (whole, somatic and gonad weight-at-age) over time, and were compared directly to corresponding AMO indices. Mean annual whole, somatic, and ovary weight-at-age all demonstrated a decreasing trend from 1970 to 2010. Excluding age, all biometrics correlated negatively with increasing AMO value (regression $p = < 0.05$). Mature female somatic weight showed significant declines between years with a mean negative vs. positive AMO index (t-test $p = < 0.05$). A similar trend was observed for the mean ovary weight of reproductive females (t-test $p = < 0.05$) demonstrating almost a twofold decrease (~44%) compared to somatic weight (~27%) between AMO phases. This suggests reproduction may be more adversely affected than somatic weight. A regime-type relationship where positive and negative AMO phases are coupled with inverse trends in *C. harengus* weight and reproductive potential (ovary weight) should be further investigated. Findings may provide new benchmarks for ecosystem based management of *C. harengus*.

Declining water clarity in Acadia's lakes: Trends and possible causes

Jasmine E. Saros¹, Kristin E. Strock¹, Bill Gawley², and Alan Ellsworth³

¹Climate Change Institute, University of Maine, Orono, ME

²National Park Service, Acadia National Park, Bar Harbor, ME

³National Park Service, Northeast Region, Troy, NY

Water clarity is one of the most highly valued aesthetic aspect of lakes and has significant ecological effects on the productivity and diversity of lake ecosystems. We analyzed water clarity data (measured as secchi disk transparency) collected monthly by Acadia staff since 1985 from five of Acadia's lakes (Jordan, Eagle, Bubble, Echo, and Long). Parameters that affect water clarity, including chlorophyll a, dissolved organic carbon (DOC), and nutrients, were also measured and analyzed during this period of time. These monitoring data were paired with paleolimnological techniques to provide a longer term study of lake ecosystem change, and with storm sampling to assess lake response to short term but potentially high impact events. Synthesis of monitoring data revealed synchronous declines in water clarity across multiple lakes while chlorophyll concentrations (algal biomass) were unchanged. Concentrations of DOC (which can impart a brown stain to lake waters) increased while water clarity declined. However, paleolimnological inferences within Acadia reveal little to no lake acidification over the last century. The observed changes in water clarity may be driven by the interactive effects of climate change and air pollution, specifically increased storm severity coupled with reduced sulfur deposition, but the mechanisms remain unclear. Lake water clarity is declining across multiple systems in Acadia, underscoring the need to understand the response of these systems to a changing climate in order to better inform management decisions that protect these valuable resources.

Science in Acadia: The early years

Catherine Schmitt

Maine Sea Grant, Orono, ME

The first scientists to visit the Mount Desert Region surveyed the landscape for mineral resources, topographical features, and evidence of an Ice Age. The aesthetic and restorative appeal of Mount Desert Island's spectacular and diverse scenery began to attract visitors at a time when science was expanding in scope and complexity, yet still held its connections to the humanities. The origins of research at Acadia National Park can be traced to those individuals who came to study the flora, fauna, and geology of Mount Desert and surrounding waters in the late nineteenth century, people like Charles Eliot, Edward Rand, and other Harvard students and professors who studied the plants, birds, marine fauna, weather, and geology of Mount Desert Island. During the course of their work, Eliot and Rand became concerned about the future of the place, and these expressions would eventually inspire the creation of what would become Acadia National

Park. The story of early researchers like Charles Eliot and the Champlain Society illustrates the role, unique among the first National Parks, that science played in the founding of Acadia.

The calicioid lichens and fungi in the Schoodic section of Acadia National Park

Steven Selva

University of Maine at Fort Kent, Fort Kent, ME

The investigation began as a study of the calicioid lichens and fungi in the Schoodic Section of Acadia National Park in which these species were to be used in a Restricted Taxa Approach to assess the ecological continuity of the forests in this section of the park. Inasmuch as calicioid taxa can be found growing in more forest microhabitats than any other group of species, it is argued that an assessment index based on the total number of calicioid species collected at a site provides a most accurate assessment of ecological continuity than any of the other methods currently being used.

Known, collectively, as the “stubble” or “pin” lichens and fungi, because of their tiny, 1-2 mm tall, stipitate apothecia, I have been studying this group in the old-growth forests of the Acadian Forest Ecoregion for the past 25 years.

A total of 24 species, in 7 genera of calicioid lichens and fungi, were collected in vegetation sampling at a variety of locations. Eleven of these were calicioid fungi and 13 were calicioid lichens. My overall impression of the collecting on the Schoodic Peninsula—when compared to the other forests that I’ve collected in over the years, is that the calicioid specimens were noticeably “few and far between” and the calicioid lichens were in extremely poor condition. The calicioid fungi looked fine. In short, the calicioid lichens—with their photosynthetic algal component being negatively impacted by the park’s acidic air—are dying out on the Schoodic Peninsula.

Three ways to explore science in Acadia National Park

Ed Sharron and Adam Kozlowski

National Park Service, Inventory and Monitoring Program, Northeast Temperate Network, Woodstock, VT

The Northeast Temperate Network (NETN) helps Acadia National Park document and track the ecological health of many of its natural resources. Knowing the condition of natural resources in National Parks is crucial for the NPS to fulfill its mission of keeping parks “unimpaired for the enjoyment of future generations”. Making this information readily available and easily digestible is also a vital function of NETN. Google Earth, IRMA, and the NETN website are three of the many sources for park managers, scientists, schools, and any other interested parties to access natural resource studies taking place in the National Parks of NETN.

A multi-proxy study of environmental change in Acadia National Park

Kevin M. Spiegel

Unity College, Unity, ME

Abrupt environmental changes documented in several paleo-records including lake sediments provide evidence that climate is not static, but responds systematically to a variety of forcing mechanisms. Rapid climate change during the Younger Dryas Chronozone (YDC) has received widespread attention for reasons including rates of change, causes, and wildfire activity. Evidence for this cold interval is present in lake sediment records from across North America. In Maine, however, records are spatially heterogeneous and are best preserved in ponds from northeastern Maine. Preservation of sediment records from elsewhere in Maine were confounded by re-advances of remnant glacial ice in response to significant cooling during the YDC and by the incursion of marine water caused by isostatically-depressed coastal landmasses. Sediments from The Bowl, a small lake in Acadia National Park, contain evidence of the Younger Dryas climatic event inferred from high-resolution loss-on-ignition (LOI) analysis. Recent work has produced a high resolution environmental magnetism data set that provides new insight on this major climate event. There is a need for robust high-resolution, multi-proxy sediment records from Maine lakes capable of providing insight on environmental responses to past climate change events that could yield information about possible landscape responses to future climate change. This dataset provides valuable information related to environmental changes and deglaciation chronologies during the Post-Glacial period in Maine.

New technologies reveal foraging behavior and migratory pathways of pelagic seabirds

Linda Welch

U.S. Fish and Wildlife Service, Maine Coastal Islands National Wildlife Refuge,
Milbridge, ME

Maine Coastal Islands NWR (MCINWR) is using a variety of new technologies to document foraging behavior and migratory pathways of pelagic seabirds. Working with a graduate student from UMASS, we attached temperature depth recorders to Atlantic puffins to determine the frequency and characteristics of foraging dives. Our data shows that most puffins foraged within 25 km of the Petit Manan colony, on average birds dove 276 times per day, and most dives were less than 15m. In 2010 and 2011, MCINWR placed satellite tags on greater shearwater to document migratory pathways and habitat use of pelagic seabirds in the Gulf of Maine. The objective of the study is to determine how environmental change resulting from climate change or offshore development may influence pelagic species in this region. The Refuge has tagged 11 shearwaters during the

past two summers and has been able to follow the birds foraging and migratory flights for up to 7 months. On average the birds travelled 1,800 km in the Gulf of Maine after being tagged and travelled up to 44,500 km to reach their breeding colonies in the South Atlantic. In 2010, MCINWR and National Audubon Society placed small geolocators on Arctic terns to document the birds' annual migration to the Southern Hemisphere. This is the first effort to track Arctic terns breeding in North America. We were able to recapture 11 of the terns when they returned to their breeding colonies in 2011. The data is currently being analyzed.

Seabird restoration efforts at Maine Coastal Islands National Wildlife Refuge

Linda Welch and Sara Williams

U.S. Fish and Wildlife Service, Maine Coastal Islands National Wildlife Refuge,
Milbridge, ME

Arctic, common, and roseate tern populations were decimated in the Gulf of Maine in the late 1800's due to a combination of shooting and eggging for use as food and bait. Thousands of terns were also harvested to provide feathers for the growing millinery trade. For more than 25 years, Maine Coastal Islands National Wildlife Refuge has been working to restore tern and Atlantic puffin colonies to the coast of Maine. The initial step in the restoration effort involves removing the nesting population of great black-backed and herring gulls from former tern and alcid nesting islands. Gulls prey on the eggs and young of numerous seabird species, and compete with the terns for preferred breeding sites. After gulls have been removed from the island, the Refuge has utilized social attraction techniques (i.e. decoys and sound recordings) to encourage terns and puffins to nest on the islands. All three species of terns have experienced significant population growth as a result of the combined efforts of Maine Coastal Islands NWR and our conservation partners in the Gulf of Maine Seabird Working Group. Research efforts on the restoration islands have focused on diet composition, productivity and growth rates, interactions among the seabirds, alcid foraging ecology, movement among the colonies, and habitat management. Razorbills, laughing gulls, and common eider have taken advantage of the gull-free environment on our seven restoration islands, resulting in diverse and highly productive seabird colonies scattered along the Maine coast.

An investigation of the opening and closing of the tidal inlet on Sand Beach, Acadia National Park, ME

Lauren Wheeler

University of Maine, Orono, ME

Rising sea level is driving small, pocket beaches landward into progressively smaller embayments. With shrinking embayment size, the tidal prism of the beach-protected estuary also decreases and eventually reaches the point where tidal inlets cannot remain open. For smaller inlets, like the Sand Beach Inlet in Acadia National Park, ME, there are significant ecological implications related to the opening and closing of an inlet. Other studies on inlets in different climates implied that the status of the inlet depended largely on seasonal variations that were easily predicted. To understand the factors that control the ephemeral Sand Beach Inlet, two Aqua Troll 200s were placed in the lagoon to gather temperature, salinity and water-level data to investigate any associations the water depth had with associated tidal, precipitation events, and wave data. In the Sand Beach Inlet this is not the case, a more detailed analysis was undertaken. Precipitation, wave height data, tidal data, and storm data on an hourly to daily basis were all necessary to predict the extremely dynamic tidal inlet on Sand Beach. Precipitation events can open the inlet and storms can both open and close the inlet by depositing or removing sand from the inlet opening.

Population genetics of estuarine fish of Acadia National Park: Connectedness among estuaries in Downeast Maine

Charles Wray¹, Elena Correa², and Chris Petersen³

¹Mount Desert Island Biological Lab, Salisbury Cove, ME

²Colorado College, Colorado Springs, CO

³College of the Atlantic, Bar Harbor, ME

Fundulus heteroclitus (the common mummichog) and *Menidia menidia* (the Atlantic silverside) are species of minnow, sharing the same estuaries in Acadia National Park, Maine. *M. menidia* leaves the estuaries every year, while *F. heteroclitus* are rarely found elsewhere. We took population samples of each species from four different estuaries in ANP and used 8 different microsatellite loci to assess whether or not there is a difference in the levels of genetic diversity and gene flow in the two fish species. Analyses included allelic richness, expected heterozygosity, and F_{ST} a measure for pairwise differentiation between sites. The *M. menidia* populations were more diverse by allelic richness ($p=9.2 \times 10^{-9}$), expected heterozygosity ($p=4.2 \times 10^{-8}$), and observed heterozygosity ($p=2.1 \times 10^{-5}$) than *F. heteroclitus* populations. F_{ST} values were all relatively low, *F. heteroclitus* with an average of 0.126 and *M. menidia* with an average of 0.065, and there was no significant difference between them ($p=0.059$).

Prioritizing aquatic habitat restoration in Maine

Jed Wright¹, Alex Abbott¹, Mao Lin¹, Curtis C. Bohlen², and Christina Bilodeau²

¹U.S. Fish and Wildlife Service, Gulf of Maine Coastal Program, Falmouth, ME

²Casco Bay Estuary Partnership, University of Southern Maine, Muskie School for Public Service, Portland, ME

Industrialization, construction of dams, and development of road networks has severely restricted movement of aquatic migratory species within the majority of Maine's river systems. Road-stream crossings that are barriers to fish passage are usually undersized from a hydraulic perspective, creating flooding risks which are likely to get more severe due to climate change factors. Gulf of Maine Coastal Program is working with partners to survey fish passage barriers, prioritize removals, and restore access to historic habitat for diadromous fish species.

Meaningful research, meaningful learning: A framework for participatory science in high schools

Bill Zoellick¹, Sarah J Nelson², Hannah Webber¹, Beth Bisson³, Molly Schauffler⁴

¹SERC Institute, Winter Harbor, ME

²Senator George J. Mitchell Center for Environmental and Watershed Research, University of Maine, Orono, ME

³Maine Sea Grant Program, Orono, ME

⁴Center for Research in STEM Education, University of Maine, Orono, ME

For the past five years the Schoodic Education and Research Center (SERC) Institute, with partners the Senator George J. Mitchell Center for Environmental and Watershed Research and Maine Sea Grant at the University of Maine, has engaged high school teachers and students in fieldwork to collect samples and data used in a study of spatial patterns of mercury (Hg) and methylmercury (MeHg) across the northeastern US. This program's success in producing useful scientific research data and achieving formal science education outcomes has resulted in new funding for both the scientific work and the education work. SERC Institute and the Mitchell Center are now applying the pedagogical and scientific framework underlying this work to address new research related to seasonal variation in nitrogen in watersheds, demonstrating that the framework has applicability beyond studies of Hg. Core elements of the framework that essential to the success of this kind of participatory science are: (1) approaches to structuring research designs to ensure that data collected by students is scientifically useful; (2) the need to assist teachers in supporting a research focus by students that differs from the research undertaken by working scientists; (3) pedagogical strategies to support this student research; (4) mechanisms to support peer review and publication of student research, creating over time a body of student work that supports new student research and that is a potentially useful resource for others.