PROCEEDINGS OF THE ACADIA NATIONAL PARK SCIENCE SYMPOSIUM

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Summary

The 2018 Acadia National Park Science Symposium, held at the College of the Atlantic (COA) in Bar Harbor, brought together over 100 researchers, students, and park staff to discuss science taking place in and beyond park boundaries. The symposium featured three sessions with multiple speakers as well as ## posters describing results and plans for research in a range of disciplines, including natural sciences, social sciences, and humanities.

The speakers at the event were:
Session 1: Engaging students in science education and research at Acadia National Park
Kate Ruskin - University of Maine - Integrating undergraduate education, stakeholder-driven research, and service through ongoing partnerships
Hannah Podurgiel - Mount Desert Island High School - The power of place - Using Acadia as an outdoor science classroom
Hannah Webber (for Richard Feldman) - Schoodic Institute - Citizen science for all ages: How students and youth have been tracking ecosystem change on Acadia's Schoodic Peninsula
Sidney Anderson - College of the Atlantic - Acadia Scholars Program: Wildlife Intern
Celeste Crowley and Vanessa Taylor Cañon - College of the Atlantic - Watershed monitoring in Acadia National Park: Collaborative internship between COA and FOA Summer 2018
Hope Kohtala - University of Maine - Understanding visitor risk perceptions of Lyme Disease in Acadia National Park
Sara McBride - University of Maine - Patterns and mechanisms of Lyme Disease exposure risk in Acadia National Park
Mark Royer - University of Maine - The P301 workbench for studying climate data

Session 2: Managing success: Using science to preserve resources and protect visitor experiences at Acadia National Park
Charlie Jacobi - Retired National Park Service - The science behind transportation planning
Abbie Larkin - Resource Systems Group, Inc. - Managing success: Modeling the plan
Rachel Collins - National Park Service - ***

Session 3: Science for a second century of stewardship in National Parks
Alessio Mortelliti - University of Maine - Squirreled away: How climate change and small mammals will reshape Acadia National Park
Allyson Jackson - Purchase College - ***
Chris Nadeau - University of Connecticut - Why are you staring in that puddle?

Allie Gardner - University of Maine - Socio-ecological dimensions of tick-borne disease risk in Acadia National Park
Jenny Smetzer - Smith College - Incorporating climate change refugia into climate adaptation in the Acadia National Park region

For more information on Schoodic Institute and research in Acadia National Park and surrounding areas, please see:
http://www.schoodicinstitute.org/

Session Abstracts

Session 1: Engaging students in science education and research at Acadia National Park

Students and teachers from K-12 through graduate levels actively engage in science and research in Acadia. In this session, we will learn about formal science education in courses and reflections from instructors about implementing this engagement. Lightning talks will highlight research conducted by students through field and classroom inquiry courses as well as independent study projects and graduate research.

Session 2: Managing success: Using science to preserve resources and protect visitor experiences at Acadia National Park

Visitation to Acadia National Park has increased by 60% in the last 10 years. Over 450 vehicles sometimes arrive to view sunrise in a summit parking that can only park 150 vehicles. The road to Cadillac Summit was closed 70 times in 2017 due to congestion. How can long-range management decisions be made to maintain access, a high visitor experience, and the resources that attract people? Learn more about the monitoring, the science, and the public engagement needed to embrace Acadia into the next 100 years.

Session 3: Science for a second century of stewardship in National Parks

Second Century Stewardship began in 2016 as an initiative to advance science and inspire audiences of all ages. The goals of the initiative are to: (1) support stewardship of park resources through advancing conservation and ecosystem science, (2) strengthen public understanding of the importance of science for parks and society, (3) increase public engagement with science, and (4) pursue solutions to critical conservation challenges. This session includes talks by five Second Century Stewardship Research Fellows, describing their work and its implications. They exemplify the type of researchers and work national parks need in the next century.

Poster abstracts

Research permits at Acadia National Park: The numbers

Emma Albee[1] and Abraham Miller-Rushing[2]

1 Schoodic Institute, Winter Harbor, Maine
2 National Park Service, Acadia National Park, Bar Harbor, Maine

A breakdown of Acadia National Park's research permits from 2001 through 2018: number of research permits each year, where research takes place, and topics of research.

Nesting and population study of painted turtles (Chrysemys picta) on two ponds in Acadia National Park

Sidney E. Anderson

College of the Atlantic, Bar Harbor, Maine

The Acadia Scholars is a two-year-old program jointly administered by College of the Atlantic and Acadia National Park. The program places two College of the Atlantic students with the National Park Service or the Schoodic Institute for a paid summer internship. Students are active partners with park service employees in Interpretation or Resource Management, working closely with their faculty and division staff and interacting with park visitors. As one of this years Acadia Scholars, I worked with the Wildlife Division of the Resource Management Division as a Wildlife Intern, conducting an independent summer-long population study of painted turtles in addition to assisting with the many other projects the wildlife team conducts throughout the summer.

Forest trends in Acadia National Park

Sam A. Bietsch, Kate M. Miller, Aaron S. Weed, and Camilla E. Seirup

National Park Service, Northeast Temperate Network, Acadia National Park, Bar Harbor, Maine

The Northeast Temperate Network Inventory & Monitoring Program (NETN) has been monitoring forest health annually in Acadia National Park since 2006. NETN monitors a suite of site and vegetation measures across a network of 176 randomly located permanent plots in Acadia. Plots are sampled on a 4-year rotating panel, such that one quarter of plots are sampled every year, and each plot is sampled every 4 years. Currently each plot has been sampled at least 3 times, allowing us to begin examining forest trends in Acadia. Overall patterns indicate that forests are succeeding to older successional stages. While this pattern is most apparent on the east side of Mount Desert Island, signals of succession are evident park-wide. Shade tolerant species are increasing in abundance, while early successional species like paper birch (Betula papyrifera) are declining. Most notably, red spruce (Picea rubens) is increasing in abundance across all strata in the forest, including seedlings, saplings, and canopy trees. Red spruce is also the most abundant understory species, occupying nearly double the percent cover of the next most abundant species of black huckleberry (Gaylussacia baccata) and lowbush blueberry (Vaccinium angustifolium). Invasive species continue to be at low levels, with invasive species documented in only 5 out of 176 plots. Red pine (Pinus resinosa) mortality from red pine scale (Matsucoccus resinosae) has been observed in the most recent 4-year cycle, although less than 1% of trees monitored by NETN in ACAD are red pine. As long as forest composition metrics remain stable (e.g., no new invasive species, stable tree condition/ forest pests, and continued regeneration), late-successional structure is expected to continue developing over time.

New bedrock geology map of Mount Desert Island

Duane Braun

Maine Geological Survey

The map of the Bedrock Geology of Mount Desert Island has finally been completed in 2018, a project that began with field work primarily in 2012 through 2015. The map is published at a scale of 1:30,000 with twice or more detail than on the previous 1:50,000 scale Mount Desert Island map published in 1988. Geologic features on the present map are much more accurately located thanks to GPS technology than on the previous map.

The map has a legend with a detailed description of each of the 33 different rock units that have now been identified on the island. There are also two cross-sections showing the interpretation of how the rock units project underground to a depth of three kilometers (two miles), one running north to south across the island and the other running west to east across the island. In addition there is a text giving a concise synopsis of the geologic history of the island. The map helps to confirm other research since the early 1990s that Mount Desert Island was a super volcano 420 million years ago. The area at that time was a large volcanic caldera 15 km (10 mi) across that had a number of major eruptions from several different pulses of magma that were intruded below the caldera surface. Since that time 3 km (2 mi) of rock has been eroded from the area. The present land surface exposes the deep interior of the volcanic magma chamber - all the different granites, diorites, and gabbros that form most of the island.

For the next 100 years: Quantifying visitation estimates in Acadia National Park

Devon R. Brock-Montgomery and Rebecca Stanley

Friends of Acadia, Bar Harbor, Maine

Quantifying visitation estimations in Acadia National Park is a complex effort due to the diverse recreational opportunities, geography, and changing patterns in visitor use in the park. A variety of methods are used to help inform this work, including utilizing traffic counters, conducting vehicle occupancy studies, and assembling site statistics from campgrounds, buses, concessionaires and ferries. In light of substantial increases in visitation after the centennial year, additional projects are being developed to update multipliers, including some that are over 25 years old. Using this suite of approaches to approach visitor use and management, these numbers can be used to support robust adaptive management for the next 100 years.

Understanding visitor risk perceptions of Lyme disease in Acadia National Park

Hope E. Kohtala, Asha DiMatteo-LaPape, Nathaniel Burke, Ashley Cooper, Alyssa Soucy, Lydia R. Horne, and Sandra De Urioste-Stone,

University of Maine, Orono, Maine

In Acadia National Park, millions of tourists and outdoor enthusiasts per year are at risk of exposure to a suite of pathogens transmitted by hard-bodied ticks, including Lyme disease. Maine has seen a five-fold increase in Lyme disease cases over the past decade, while several other emerging tick-borne diseases are also on the rise. Both visitors and residents of Mount Desert Island have recognized the growing burden on human health posed by tick-borne disease. Incidents of Lyme disease are expected to continue to increase due to a combination of biophysical and social factors. Climate change especially may increase the human population at risk of exposure to Lyme disease via increased outdoor recreation and visitation to public parks, including extended visitation in shoulder seasons (which coincide with peak periods of adult blacklegged tick activity) and an overall increase in visitor numbers due to warmer temperatures. Little is known about visitor risk perceptions and knowledge of ticks and resulting behavioral responses. Our research addresses this gap using an online visitor survey to assess knowledge of and experience with ticks and Lyme disease, behavioral responses to reduce risk and exposure, and trust in tick communication sources. We will report preliminary survey results. This research will ultimately inform visitor management decisions at Acadia National Park (i.e., areas to facilitate/limit visitation, visitor behavior to encourage/discourage) to reduce risk of exposure, help public health interventions to more effectively address gaps between risk and perceived risk, and inform education strategies (i.e., exhibits, ranger-led talks, school programs) to enhance risk communication messaging.

Insights into stream water quality: Bacteria sampling at the Cromwell-Kebo Brook watershed through summer storm events

Vanessa Taylor[1], Celeste Crowley[1], Sara Löwgren[1], Patricio Gallardo García Freire[1], Sarah R. Hall[1], and Brian L. Henkel[2]

1 College of the Atlantic, Bar Harbor, Maine
2 Maine Natural History Observatory

Previous and ongoing water quality, discharge, and bacteria sampling has been conducted in the Cromwell/Kebo watersheds of Mount Desert Island as part of Wild Acadias Watershed Project. With five gauging locations throughout the watershed, stream stage and water temperature data have been recorded during April through September whenever streams were flowing. One location near Sieur de Monts Springs was dry through late July and August. Various sites were designated for sampling along the streams both before and after discharge pipes input water from local residences, the Bar Harbor Transfer Station, and the Kebo Golf Course. We aimed to sample the water

and collect water parameter data from each location at least three times through a storm event, before, during, and after the peak precipitation. Data collected during two summer storm events shows elevated bacteria concentrations at locations along Cromwell Brook. Further, preliminary data suggests a correlation between turbidity and bacteria concentrations, as well as possible point sources of pollution draining into the Cromwell/Kebo system. Continued monitoring of stream discharge and water quality is important for managing water resources through changing seasonal flow. As such, these monitoring efforts will be continued through the fall and will resume in the spring.

Watershed monitoring in Acadia National Park: data collection and internship opportunities

Celeste Crowley[1], Vanessa Taylor Cañon[1], Sarah R. Hall[1], and Brian L. Henkel[2]

1 College of the Atlantic, Bar Harbor, Maine
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Through a summer internship opportunity with the Watershed Project of the Wild Acadia Initiative, undergraduate students conducted watershed research in and around Acadia National Park. During summer 2018, the students monitored gauging stations and collected weekly stream discharge measurements in five watersheds: Duck Brook, Breakneck Brook, Stanley Brook, Jordan Stream, and Cromwell/Kebo Brook. Beyond the regular weekly monitoring schedule, students collected bacteria samples during storm events of targeted locations within the Cromwell Brook watershed, as well as delineated stream segments with GPS mapping techniques. By the end of the internship, students acquired employable field techniques for monitoring watersheds, data management, and basic mapping using ArcGIS Pro software.

Upland microtopography and implications to surface water detention in Maine

Bea E Van Dam, Sean M Smith, and Kate Beard

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A notable characteristic of Maine's forested landscape is the microtopography caused by a combination of factors related to surficial geology and tree fall. These features are often on the scale of single meters wide and decimeters to a meter in depth, appearing as puddles in the landscape during intense or high magnitude precipitation events. The

surface water detention provided by the depressions can be substantial at the scale of a watershed and measurably affect runoff rates in low order streams. Generalized ranges for surface water storage capacity have been summarized in textbooks for varied landscape conditions, but little is known about how microtopography and related detention varies in Maines dominant physiographic settings defined by slope, surficial geology, and land cover conditions. With the increasing availability of high resolution elevation data, it has become possible to remotely evaluate the extent of these depressions and quantify the total upland storage capacity they may represent. In this poster we describe and quantify microtopography in several Maine settings using measurements of hillslope terrain ruggedness and depression volume. We then relate the distribution of microtopography to variations in landform and land use conditions. The implications of spatial and temporal patterns of storage to runoff generation and habitat are then considered. For our analysis, we use LiDAR data in several Maine watersheds: Cromwell Brook on Mount Desert Island; Webhannet River in Wells; Darling Marine Center campus in Walpole; two streams on Marsh Island in Orono; and our sole inland watershed on Lead Mountain in East Hancock.

Demographic differences among Acadia National Park area campers

Katharine J. Ruskin, Alyson East, and Aaron L. Strong,

University of Maine, Orono, Maine

Birding Mount Desert Rock: An observational study of the migratory birds visiting a remote island site

Nathan A. Dubrow

College of the Atlantic, Bar Harbor, Maine

Mount Desert Rock is a remote seamount island located 25 miles from the nearest mainland and is home to the Edward McC. Blair Marine Research Station owned and operated by the College of the Atlantic. As part of the field research station crew this year, I lived on the island for a nine-and-a-half-week period helping out with marine mammal research and participating in my own personal project. My project consisted of keeping a detailed record of all the bird species seen on and around the island during my

stay. This included all seabirds, shorebirds, songbirds and other various species that stopped by on their way to points further south. This analysis will look at the many different groups of birds and talk about what they're doing here. This three-acre large slab of granite boasts a healthy population of Herring Gulls with many fewer Great Black-backed Gulls, along with a few Common Eiders that are ever so lucky to raise any ducklings into adulthood. These consist of the only breeding species on Mt. Desert Rock. Although many other species visit throughout the year and predominantly during spring and fall migration, some birds tend to show up seemingly with random occurrence during periods of post-breeding dispersal. Some types of birds such as shorebirds regularly use this site as a place to rest and refuel on their southbound migration before they continue on their journey. Songbirds often find this site once they've been blown offshore and are unable to return to the mainland because of exhaustion. Most times, this isn't planned, and the birds are seemingly lost in the vastness of the Atlantic Ocean. The island also has easy viewing of pelagic seabird species, some of which are usually seen with much less frequency than we witnessed this summer. Pelagic birds were seen quite regularly, and most days you would see at least a Great Shearwater. The three other regularly occurring shearwater species were also seen at various times during the summer. A more northerly breeding tubenose, the Northern Fulmar, was also seen in the first half of the season. Storm-Petrels were also common with the occasional immense group of several thousand birds. A more shocking observation were the numbers of skua seen throughout the summer, around thirty-five. All three jaeger species were also seen. Nineteen species of shorebirds were recorded, including a few harder to locate species for the area. Along with the breeding species of gulls, four others visited the island. The four expected species of alcids all stopped by in the nearby waters, but none made landfall. Predatory species included an Osprey, a Peregrine Falcon, and a couple Merlin. For passerines, or perching birds, there were forty different species. For all of these birds, this site was an incredibly important plot of land for where they could stop by and refuel before they continued on again. Many birds get blown of course at night and end up over the ocean once the sun rises and must then find somewhere to land or run the risk of falling into the ocean from exhaustion. The arrival of these birds also coincided with fall migration and the presence of north and northwesterly winds which would carry the birds from the mainland and bring them out to sea. Mount Desert Rock is a desolate and barren island in the Gulf of Maine, but is an incredibly important stopover site for migratory birds which accidentally find their way out there. Old and incomplete records show that a couple hundred species have utilized this island in one way or another and continues to remain an important location for many different species of birds. It's important to continue to get more complete bird observations to show which birds are using the site as time goes on and see how they compare to what we had in the past. This includes keeping track of all the gull numbers, as well as all the small birds. Mount Desert Rock is a special place and must be thoroughly explored to see what it's capable of attracting, and thankfully, it's small enough that you don't need too many people to cover it.

Multi-decadal evolution of nitrogen dynamics at the Bear Brook Watershed in Maine

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Chronic elevated nitrogen (N) deposition has altered the N status of temperate forest ecosystems in North America, with significant implications for forest productivity, nutrient transformations, ecosystem nutrient retention, and surface water chemistry. The Bear Brook Watershed in Maine (BBWM) is a paired whole watershed manipulation experiment focused on the effects of N and sulfur (S) deposition on ecosystem function. N was added bimonthly as (NH4)2SO4 to one watershed (West Bear) from 1989 to 2016. Research at the site has studied the evolution of ecosystem response to both treatments and ambient changes in the chemical and physical climate over time, in particular, declining S and N deposition and warmer, wetter climate in the Northeast. Here, we synthesize results from three decades of research on streams, soils, and vegetation to describe the long-term effect of N deposition at BBWM. While N leaching and export increased almost immediately in West Bear, labile soil N (ammonium, NH4+ -N and nitrate, NO3- -N) did not increase in West Bear until the fifth year of treatment. Labile N became increasingly available in West Bear over time, and after 25 years of treatment, West Bear soils had 10X more extractable NH4+ -N and 100X more extractable NO3- -N than the reference watershed (East Bear) soils. Stream exports of N from East Bear declined by 95% from 1990 to 2016 to approximately 0.05 kg ha-1 Yr-1, consistent with declines in ambient N deposition. In comparison, exports from West Bear were approximately 5 kg ha-1 yr-1 and remained constant. Chronic N additions increased N availability and reduced percent N retention in the ecosystem. The study illustrates how long-term data are essential to capture the evolution of ecosystem response.

Implications of rapid climate change on lake algal ecology in Acadia National Park, U.S.A: A case study on Seal Cove Pond

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Recent work has shown that average water clarity of lakes in Acadia has been decreasing since 1995. This decline corresponds to an increase in dissolved organic carbon (DOC) concentrations across the same set of lakes. It is believed that rapid changes in climate conditions and patterns of atmospheric deposition have resulted in these shifts in DOC and subsequent declines in water clarity. In particular, extreme precipitation events are sometimes correlated with elevated lake water DOC concentrations. Changing phytoplankton community structure may be a consequence of these fluctuations in DOC from extreme precipitation events. We analyzed a sediment core from Seal Cove Pond to create historical algal pigment and diatom reconstructions, and evaluated modern responses of phytoplankton community structure to storm events in Seal Cove Pond. From the 1990s to present, many algal pigments increased in the lake sediment record, while some declined. Shifts in pigments within algal groups may indicate that certain taxa have gained competitive advantages with changing environmental conditions that mediate light, nutrient availability, and water temperature. The diatom record shows that Discostella stelligera, an indicator of lake thermal structure, has increased since the beginning of the record in 1880. The highest relative abundance occurred in recent decades, which may reflect observed trends in increasing water temperature and DOC. In water samples from 2016, phytoplankton responded differently to precipitation events in the spring and fall, with increasing total algal biovolume after spring storms and decreasing total algal biovolume after fall storms. Phytoplankton community structure also differed between spring and fall. Certain phyla, such as chrysophytes, may have a competitive advantage over other phyla with increased storminess. It is our goal that these results will be useful for informing resource management plans for lakes and ponds in Acadia National Park.

Past, present, and future: A COA watershed assessment

Patricio Gallardo García Freire and Sarah R Hall

College of the Atlantic, Bar Harbor, Maine

In this study, I established a baseline characterization of the COA Stream (COAS) and its respective COA Watershed (COAW). The project was guided by 4 spheres of study: The Spatial, Social, Ecological, and Economic Spheres. I identified changes in land use, land ownership, and water infrastructure through time within the COAW that may have led to the current configuration of stormwater outlets, drinking water mains, and sewage piping. Using GIS, I created a database with relevant geological, hydrological, and ecological data for the COAW, to be expanded through future research questions. Given the substantial landscape changes associated with the Route 3 Reconstruction and the

future construction of the Center for Human Ecology, a new building proposed for the COA campus, I established monitoring stations at all the freshwater outlets of the COAW draining to Frenchman Bay, with the objective of involving the community in a variety of field methods, including discharge, stage, channel geometry, pebble counts, and water quality metrics. This information is of crucial importance for decision makers involved in politics, conservation, restoration, education, and infrastructure projects. With this study, I developed a framework for continued monitoring of useful ecological, economic, and social sustainability variables at the watershed scale. This assessment accounts for impacts arising from land, water, energy, and waste management decisions made at the community level, while identifying spatial, hourly, seasonal, and annual trends in watershed conditions that inform stakeholders on appropriate mitigation and best management strategies (BMPs) to be applied in future infrastructure and restoration projects. In this sense, Wild Acadias Watershed Project serves as an opportunity to apply this study's human ecological approach at other watersheds of Mount Desert Island in and around Acadia National Park which also drain to Frenchman Bay and the overarching Gulf of Maine system, while contributing to the overall ecological, economic, and social integrity of regional waterways.

Strategies for integrating long-term air and water monitoring at Acadia National Park

William G. Gawley, Shannon P. Wiggin, and Kelly M. O'Neil

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Acadia National Park (ANP) has been fortunate to participate in several long term air and water monitoring programs dating back to the early 1980s. More recent efforts, such as the NPS Vital Signs Inventory and Monitoring Program (I&M Program), are approaching 12 years of data collection. Still later projects, the Jordan Pond Water Quality Project, and the Wild Acadia Program, have introduced continuous data collection and watershed-focused investigations into the mix. Park natural resource managers are investigating approaches to better integrate both the workflow and findings of these various programs in order to enhance their ability to determine status and trends, detect abnormal conditions, and better understand the dynamic nature of park ecosystems.

Associations of blacklegged ticks and European fire ants on Mount Desert Island

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Rising blacklegged tick (I. scapularis) abundance has been documented in Maine for nearly thirty years. I. scapularis has been a growing concern in Acadia National Park, where tick habitat often coincides with the natural areas that are trafficked by visitors, residents and staff. A second pestiferous species, the invasive European fire ant (M. rubra), was first reported on Mount Desert Island as early as the late 1960s and is now infested in very high densities within isolated areas of MDI. Ants are known to prey on ticks, and it can be assumed that these two species, both of whom tend to inhabit leaf litter and underbrush in deciduous forests, must engage in some interaction. The aim of this project is to determine the effect of M. rubra on I. scapularis abundance and disease prevalence, which will help improve the development of management practices for both of these pests. To measure the effect of M. rubra on I. scapularis abundance, ticks were sampled at eight sites with high ant infestation, and eight control sites with no detectable M. rubra presence. The control sites and experimental sites were paired and in close proximity to each other and contained similar habitat features, including plants, canopy and groundcover. Ticks of all three life stages (adult, nymph and larvae) were collected in July and August. The difference in tick abundance at control vs. experimental sites was not statistically significant. In addition to their direct effects on ticks, M. rubra infestations can afflict small mammal populations, which in turn could alter tick and disease ecology, given that larvae and nymphs depend largely on mice to get the blood meals they require for molting. Track plates were deployed at each site in order to measure the effects of M. rubra on small mammal activity. Pathogen testing will be performed to determine whether the ants had a measurable effect on disease prevalence.

Acadia National Park island forests: 25 years of change and stability

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

The islands managed by Acadia National Park in the Gulf of Maine provide critical habitat for a variety of plant and animal species, including disjunct populations of alpine and arctic plant species and nesting seabirds extremely vulnerable to climate change. During 1992 and 1993, the National Park Service, with help from Earthwatch volunteers inventoried biota on 10 islands. With continuing climate change, including increased

extreme precipitation events, warming temperatures, and sea level rise, updating the parks management plans to address the projected impact of climate change on the vulnerable natural resources of these islands is more important than ever. To provide updated information on island dynamics, trajectory of forest change, important environmental drivers, and potential implications for plant and animal species, we resampled the 33 permanent historical forest plots established on 8 islands during the early 1990s. Field crews of Schoodic Institute staff, National Park Service managers, and Earthwatch volunteers resampled the historical plots, including tree, sapling, seedling, and shrub layers. Sampling concluded in September 2018 and here we present preliminary analyses comparing current and historical island forest vegetation.

Population inventory of Leach's storm petrels (Oceanodroma leucorhoa) on Great Duck Island

Chloe Hanken and Gemma Venuti

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The breeding biology of Leach's Storm-Petrel (Oceanodroma leucorhoa) is challenging to study. Pairs nest in underground burrows to which they return to and leave from exclusively at night, and not all burrows in a given colony are occupied every year, creating marked difficulty in determining population numbers. Censuses are time intensive and often unreliable due to the frequency of false positives (non-breeding birds roosting in burrows) and false negatives (missed breeders). Great Duck Island, located in the Gulf of Maine, is thought to hold the largest colony of Leach's Storm-Petrels in the Northeastern United States. Population estimates have varied drastically since the colony was surveyed in 1977, due largely to differences in census methodology. This paper reports results of the most recent census, comparisons with past numbers and methodologies, and attempts to standardize protocols for future data collection. The census, based on a 2002 study, employed six island-wide east-to-west transects. Each transect was subdivided into two by twenty meter survey plots individually sampled for burrow occupancy using playbacks, stick lattices, game cameras, and grubbing. Previous research has shown evidence of preferential nesting in forest edge areas, burrow clustering on the southeastern (leeward) side of the island, but widespread low-density nesting throughout the island. Difficulties in censusing has great implications in terms of future conservation efforts. Although Leach's Storm-Petrel is currently considered a species of least concern, the population could change dramatically and these changes would go largely unnoticed. Further standardization of protocols is an essential step in reliable population estimates.

Bat Watch: Using citizen scientists to collect bat monitoring data to inform management decisions at Acadia National Park

Chris Heilakka and Bruce Connery

National Park Service, Acadia National Park, Bar Harbor, Maine

Since the federal listing of the Northern long-eared bat, Acadia National Park is required to conduct monitoring for section 7 compliance purposes. The monitoring of key infrastructure: trails, roads and buildings are important to maintain the visitors experience. Some of these structures are too big to properly survey without additional resources. A combination of outreach and education has led to the creation of Bat Watch. A group of citizen scientist who want to learn about bats in Acadia National Park and help the wildlife staff collect data to maintain key infrastructure at Acadia National Park.

Multi-system passive warming chamber design and deployment

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Recently, there has been a large push for field based experiments in climate change research due to the complexity of community interactions and the extreme difficulty of modeling such interactions in the lab (Stewart et al. 2013). In areas with multiple ecosystems, there is an additional challenge of understanding the effects of climate change across the different systems. Acadia National Park (ANP) is one such place. We investigated the potential for building and deploying passive warming chambers in terrestrial and intertidal zones to better understand community-level effects of climate change. Passive warming chambers (PWC) are open or closed top chambers constructed of clear fiberglass that harness the power of the sun to raise ambient air temperature by 2-5 C inside the chamber. Our PWCs utilized different chamber designs, hexagonal for the blueberry plants and cone for the intertidal, to best suit the varying pressures exerted on the different ecosystems. In both terrestrial and intertidal settings, we

deployed experimental PWCs, control chambers, and had control plots. The intertidal treatment cone was significantly effective at warming ambient air temperature inside the cone during low tide, while still allowing water flow during high tide (1-Way ANOVA, F = 385.4, df = 2, 48843, p-value < 2e-16). The experimental PWC (22.73 0.72 C) was on average 2.83 C warmer than the control plot (19.9 0.52 C) during low tide, representing a more extreme climate change model; the control chamber (21.27 0.60 C) was on average 1.37 C warmer than the control plot, representing a moderate climate change model. The terrestrial PWCs were also effective at warming ambient air temperature, while keeping other abiotic factors the same, including: soil moisture and temperature and relative humidity. The ambient air temperature of the experimental PWC was significantly warmer than the control chamber and plot (1-Way ANOVA, F = 540, df = 2, 104563, p-value < 2e-16). During the day, the average ambient air temperature of the treatment PWC (26.12 1.67 C) was 4.02 C warmer than the control chamber and plot (22.10 1.53 C). We present initial abiotic data on warming within the chambers as well as planned future research on biotic responses to warming.

Project based learning: Wildlife survey of Four Foot Farm

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We conducted an 8-week-long wildlife survey of Four Foot Farm, Bar Harbor, Maine for the Wildlife Ecology course at College of the Atlantic. The objective of this course was to familiarize students with the theory and methodology of wildlife biology through a hands-on wildlife survey project and to develop and expand upon an on-going database for the North East Creek watershed. The class surveyed three sites at the upper, middle, and lower reaches of North East Creek. Our study focused on land adjoining the lower (northern) end of the creek. The Four Foot Farm study site included the farm property and extended to the adjacent pasture owned by Acadia National Park. Our groups objectives were to conduct a baseline survey of the field site before grazing animals are introduced and to investigate the animal usage of natural and artificial corridors. We mapped the features of the study site using a Trimble XT GPS unit and used ArcGIS Pro 2.1.1 software to create a comprehensive image of the general landscape. We conducted field surveys on the pasture, placed game cameras, small- and large-mammal traps, sand traps, cover boards, and birdhouses to investigate vertebrate-usage of the study site. At least 9 different species of wildlife were captured by our game cameras and 151 total signs of animal presence during our field survey. Animal hotspots were located around vernal pools and corridors which indicated the usage of predicted corridors and vernal pools by the wildlife. This project provided us with an opportunity to gain various

technical skills for collecting, interpreting, and comprehending data, as well as the experience of research design.

Integrated transportation and visitor use modeling to help inform the Acadia National Park Transportation Plan

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The National Park Service is developing a Transportation Plan for Acadia National Park in order to determine how best to provide safe and efficient transportation and a variety of high-quality experiences to visitors within Acadia National Park, while ensuring the protection of park resources and values. To help inform the transportation planning process, RSG developed simulation models of transportation and visitor use on the summit of Cadillac Mountain and in the Ocean Drive Corridor. The simulation models were developed to provide precise, quantitative information about traffic, parking, visitor use, and crowding conditions in the two study areas. The models also provide scientifically rigorous estimates of the maximum number of visitors and vehicles that can be accommodated per day without exceeding physical parking-related and potential crowding-related capacities in each study area. The results of each simulation model were used to estimate current conditions of transportation and visitor use, and to assess whether current levels of peak summer season visitation exceed preliminary draft thresholds for potential parking- and crowding-related indicators of quality. This poster provides an overview of the methods and results of the simulation models developed for the summit of Cadillac Mountain and the Ocean Drive corridor.

Recruitment to the rocky intertidal zone in the Gulf of Maine: Patterns and processes at local and regional scales

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Rocky shores in the Gulf of Maine (GoM) provide a model system to examine the processes that structure and dynamics of natural communities across small and large spatial scales. Throughout the GoM, rocky intertidal communities consist of the same species although community structure, dynamics and productivity differ markedly among three distinct regions: southern, central/Penobscot, and northern/Downeast. Past influential work, conducted primarily in the southern and central GoM, focused on local processes and produced very different conceptual models of these communities are structured. Here we assess variation in the recruitment of key foundation species (blue mussels Mytilus edulis and acorn barnacles Semibalanus balanoides) across local (~1km) and regional (~100km) scales for the past four years. We found that recruitment increased with wave-exposure at local scales and decreased with latitude at regional scales, peaking at field sites in northern Massachusetts and southern Maine. The timing of peak recruitment also varied along the coast: both mussels and barnacles recruited later with increasing latitude. Because algal canopies also vary in composition and density at both spatial scales, we conducted a manipulative experiment to test canopy effects on community recovery (recruitment of mussels, barnacles, and macroalgae) following simulated disturbance. Algal canopies tended to inhibit recruitment in the northern GoM but enhance recruitment in the southern GoM. Ongoing experiments aim to disentangle the roles of consumers, population connectivity, and physical transport processes to ultimately develop a framework of how large-scale environmental forces interact with local processes to control the structure and dynamics of these communities. Understanding the interaction between processes operating at different scales is fundamentally important to developing more reliable models that can be used to predict community dynamics, with implications for commercially important species and ecosystem management within the GoM.

Deciduous trees of Great Duck Island

Coral Matos

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The forests of Great Duck Island are typically described as consisting primarily of spruces. There is little information about the species of deciduous trees, their location, or their abundance on the island. Knowing these details would provide clues to aid in developing a working understanding of the natural history/ecology of the area. Plotting the density and distribution of these trees on GDI can give insight into land use. This project focused on using a Trimble, a GPS tool, to map where the deciduous trees are

most prevalent on the island. This research will be valuable in understanding the forest ecology and land use history of Great Duck Island.

Invasive species trends in Northeast Temperate Network park forests

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The Northeast Temperate Network (NETN) has been monitoring forest health in a network of permanent forest health plots spanning 8 northeastern national parks since 2006. Over this time, parks forests have encountered multiple agents of change, including extreme storm events, such as Hurricane Sandy in 2012 in Morristown National Historical Park (NHP) in NJ, new infestations and the subsequent impacts of emerald ash borer in Roosevelt-Vanderbilt National Historic Site (NHS) in Hyde Park, NY, increased impacts from deer overabundance in nearly all but Acadia National Park (NP), and new invasions and expansion of exotic plant species. Here we present preliminary findings from the last 13 years of monitoring in NETN park forests, with special emphasis on trends in invasive plants. We used linear mixed models and generalized linear mixed models for a range of invasive metrics to determine how invasive plants are changing over time and potential implications for native plants. We assessed multiple scales and metrics of invasion, including proportion of plots invaded, frequency of 1m2 quadrats invaded, average percent cover of invasives, and invasive species richness. We assessed trends in invasive plants overall, and by the following guilds: trees, shrubs/vines, graminoids, and herbs. Parks vary considerably in their degree of invasion, with Acadia NP being the least invaded and Morristown NHP the most invaded. However, at all scales and in nearly every park, a consistent trend has emerged: invasive shrubs/vines continue to invade new areas and increase in abundance where they already occur. These trends are especially strong where major forest disturbances have recently occurred, such as Hurricane Sandy in Morristown NHP. Results indicate that eradicating invasive shrubs and vines, such as Japanese barberry (Berberis thunbergii), oriental bittersweet (Celastrus orbiculatus), and exotic bush honeysuckle (Lonicera spp.), before they become established should be a high management priority. Managing existing populations of exotic shrubs and vines is also necessary to keep them from continually expanding and invading new areas.

Second Century Stewardship: Science for America's National Parks

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Second Century Stewardship began in 2016 as an initiative to advance science and inspire audiences of all ages. The goals of the initiative are to: (1) support stewardship of park resources through advancing conservation and ecosystem science, (2) strengthen public understanding of the importance of science for parks and society, (3) increase public engagement with science, and (4) pursue solutions to critical conservation challenges. The project partners achieve these goals by providing research fellowships and communication training, by enhancing park education activities and school curricula, and by convening leaders to pursue solutions to critical challenges. Second Century Stewardship has achieved early successes and promises to continue to grow its impact in Acadia National Park and throughout the National Park Service.

Using environmental STEM (ESTEM) studies and professional development skills to explore natural environments

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The three year NSF-GEOPATHS field based professional development program for ESTEM undergraduates has provided two cohorts of students from three different academic institutions field training and professional networking. The program objectives are: (1) increase students awareness of and access to a broad group of local professionals working in the environmental sector, (2) provide opportunities for students to read and discuss scientific literature, and (3) facilitate student understanding of potential pathways to future careers. Two new courses were created in pursuit of these goals: a field methods course during June 2017 and 2018 in Eastern CA and a professional development seminar at each home institution. Students engaged in field-based techniques to practice skills required for environmental careers, completed a variety of

field projects in geology, geomorphology, hydrology, and botany, and engaged with stakeholders working in various environmental careers. To date this program has trained over 40 undergraduates through a collaboration of faculty from College of the Atlantic (COA), University of San Francisco, and Mt. San Antonio College. Following the summer field course, COA students enroll in the ESTEM professional development seminar where they engage with local stakeholders and ESTEM professionals in the MDI region, and learn a new skill of their choice. Students are encouraged to network with local stakeholders particularly relevant to their personal career ambitions. Preliminary data collected through surveys and curricular material assessments suggest that this program has enabled students to gain both awareness of the skills and content knowledge needed for ESTEM careers as well as competency in a range of field based and other professional skills. Students will present on their experience of field based learning and their interactions with local stakeholders working in and around Acadia National Park.

Sedimentary architecture and accumulation rates of multiple lakes in Maine

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The sedimentary architecture of lakes in previously-glaciated landscapes records geomorphological history that can shed light on the nature of late-glacial, periglacial, postglacial, and anthropogenic landscape change. Unfortunately, the sedimentary architecture of most lakes is not well understood, since they are most often studied using point-source sediment collection. Maine's lakes are especially interesting given the wide variety of geologic settings they encompass, particular among them the influence of lowland postglacial marine transgression. We conducted ground-penetrating radar (GPR) and side-scan sonar (SSS) surveys of multiple lakes in Maine, including The Tarn in Acadia National Park, representative of different basin types and landscape histories since the retreat of the Laurentide Ice Sheet. Combined with coring, the results suggest very slow (on the order of 0.1 m / kyr) accumulation over the majority of the Holocene north of the marine transgression, faster accumulation south of the transgression, and on the order of 100 m / kyr over the last century in some disturbed areas like The Tarn, likely related to farming, logging activities, construction, and increased trap efficiency of reservoirs due to dam emplacement. Geophysical results suggest accumulation may also have been faster in the late-glacial and periglacial periods, though the age and duration

of these periods are difficult to constrain without further coring and geophysical work. Maines many lakes and ponds likely provide a buffer to sediment and solute transport from inland to coastal areas. This presentation will summarize GPR, SSS, and core collection methods, assumptions and limitations, structural and surficial interpretations, and key findings including accumulation rates and implications for historic and prehistoric landscape change.

The Downeast Phenology Trail: A snapshot of citizen science in Acadia National Park and beyond

Elizabeth Orcutt, Hannah Webber, and Seth Benz

Schoodic Institute, Winter Harbor, Maine

The Downeast Phenology Trail is a citizen science project that tracks the phenology of plant species in the Downeast region of Maine. The project is a partnership between Schoodic Institute, Acadia National Park, Downeast Lakes Land Trust, Blue Hill Heritage Trust, Island Heritage Trust, Fields Pond Audubon Center, Petit Manan National Wildlife Refuge, Great Pond Mountain Conservation Trust, and Frenchman Bay Conservancy. Phenology, or nature's calendar, is the study of plant and animal life cycle events-including fruiting of plants, emergence of insects, and bird migrations. This project uses three citizen science tools, Nature's Notebook, iNaturalist, and eBird to help answer scientific research questions tracking changes in phenology and their relation to climate change in Downeast Maine. What has the citizen science effort looked like on the Downeast Phenology Trail? What are the data showing so far? What are the next steps for the Downeast Phenology Trail? As the third year of the Downeast Phenology Trail draws to close we reflect on the projects progress and visualize the projects future.

A spiny tale: The consequences of growing tail spines in the presence of predators

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Water fleas, also known as Daphnia, are keystone species in many freshwater ecosystems because of their role as grazers and prey. In the presence of predators, Daphnia often grow defensive structures such as neck teeth and helmets. Defensive structures presumably reduce predation; however, this assumption has not been tested

with a wide array of natural predators. Recent research suggests that high levels of dissolved carbon dioxide can limit the ability of Daphnia to sense predators and grow defensive structures. If defensive structures reduce predation, then human caused increases in carbon dioxide could increase predation, which could dramatically affect freshwater ecosystems. However, if defensive structures are not useful against all predators, failure to detect predators may not affect some freshwater ecosystems. We evaluated whether Daphnia magna, a keystone grazer in the freshwater rock pools at Acadia National Park, grows defensive structures in the presence of a common rock pool predator, diving beetle larvae. Second we evaluated whether Daphnia magnas defensive structures reduce diving beetle predation. Our results suggest that Daphnia magna grow long tail spines (30% of their body length) in the presence of diving beetle larvae, and also when they sense chemical cues from other Daphnia killed in their environment. Daphnia with long tail spines had an 81% probability of survival when subjected to diving beetle predation, versus only 44% for Daphnia with short spines. Follow-up work will investigate if, like other Daphnia species, increased carbon dioxide limits the ability of Daphnia magna to detect predators. If it does, then increased predation caused by increases in carbon dioxide could affect both the invertebrate community and algal growth in freshwater rock pools at Acadia.

Assessing salt tolerance in coastal vs inland breeding spotted salamanders (Ambystoma maculatum) through behavioral avoidance tests

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In Acadia National Park, Maine, USA, a population of Spotted Salamanders (Ambystoma maculatum) breeds in vernal pools that are in close proximity to the high tide zone. Breeding adults at this locale, in turn, are subject to periodic spikes in salinity that occasionally approach full strength seawater (35 ppt). As part of a long-term study on the effect of elevated salinity levels on all life history stages of this local population, we employed behavioral avoidance tests to assess the level of salt tolerance between coastal breeding adult salamanders and adult salamanders that breed in inland pools with salinity levels <1 ppt. Salamanders were collected from each site and placed in one of two adjoining test chambers that randomly contained freshwater or salt water with ion concentrations that increased incrementally from 3.9 to 17.5 ppt. We then recorded time spent by individual salamanders in either chamber over 60 minutes, testing eight salamanders per concentration. For both coastal breeding and inland breeding

salamanders, 17.5 ppt represented the threshold at which salamanders spent significantly less time in salt water compared to freshwater. The magnitude of avoidance behavior, however, was greater in coastal breeding salamanders than inland breeding salamanders (time spent in 17.5 ppt: 2.7 25.5 minutes and 13.75 60 minutes, respectively). Our data suggest that both coastal and inland breeding salamanders can tolerate increasing salt concentrations to the same upper threshold but coastal salamanders have a more rapid avoidance response to this upper threshold than that observed in inland salamanders.

A software workbench for studying past climate

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The study of past climate enables a better understanding of present and future climate conditions. However, directly measured data for temperature and other climate variables is available for only the recent past (a few hundred years). Study of climate in the more distant past, from centuries to millennia before present, requires the use of indirect methods which use other variables as proxies. Chief among such methods is the use of data derived from ice cores. Analyzing such ice-core data in order to gain insights into past climate is a complex task that requires data from diverse sources to be combined, transformed, and visualized in multiple and often novel ways. In the past, such analysis was often performed using an ad hoc collection of software tools, such as spreadsheets and plotting programs. There are two primary reasons why this past approach to analyzing data is no longer effective: First, recent technological advances in the physical and chemical processing of ice cores to extract measurements have resulted in orders-of-magnitude increase in the volume of data. Not only does this volume of data render some software tools inoperable but also it makes it difficult for a human to interpret data visually. Second, and more important, ad hoc application of multiple tools to analyze data, even when it produces usable results, typically leaves no systematic record of the precise sequence of transformations that yield a data product, such as a chart of temperature over time, from the original data sources. The P301 project addresses these shortcomings of prior data analysis methods by providing an interactive, graphical software workbench with a few notable features in this context: First, it can analyze even the largest ice-core datasets available today, and more, in interactive times (a few seconds at most). Second, it permits a scientist to interactively use, define, and compose software tools for analyzing data in diverse and powerful ways. Third, all transformations of both tools and data are automatically recorded by the system in a manner that permits examination, study, transformation, and workflow management.

Finally, the P301 workbench is notable in that it is not only a research project but also an operational tool used by several scientists in their daily work.

Chick provisioning and foraging hot spots in herring gulls (Larus smithsonianus)

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Great Duck is a 220 acre island in the Gulf of Maine and is one of the larger breeding gull colonies in the Northeastern United States. Gulls are notorious generalists and opportunistic feeders that utilize a broad range of prey types. In 2016, we began tagging nesting adult gulls on Great Duck Island using Ecotone Harrier GPS tags which permitted us to identify foraging hot spots. The goals of the present study were to continue to identify foraging and loafing hot spots of tagged nesting adult Herring Gulls (Larus smithsonianus) and to identify what prey items the gulls were feeding their chicks. Hot spots were identified through analysis of results from tagged birds. Sites were visited by boat or on foot to confirm resource availability and other habitat parameters. Prey remains were collected from food boluses regurgitated from both chicks and adult Herring Gulls and from remains in and immediately around nests. Prey included crabs and other marine invertebrates, fish, lobster bait, and other anthropogenic food sources. Our results showed that each tagged gull displayed a high degree of preference for a specific foraging or loafing hot spot, suggesting a degree of specialization by individuals. Information from this study can be used to determine potential areas of conservation concern for Herring Gulls during the breeding season.

Employing an external backpack radio transmitter to track post-breeding movements of yellow-spotted salamanders *(Ambystoma maculatum)*

Elizabeth Signore and Stephen Ressel

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Yellow Spotted Salamanders (Ambystoma maculatum) display elusive behavior, spending most of the year out of sight and presumably in underground burrows except for a few weeks during the spring breeding season. Given their habits, it is difficult to study their behavior throughout the year unless previous measures are taken to follow their terrestrial. Previous studies have used passive pitfall traps to provide data on the general direction of travel from vernal pools, while other studies employed implantable radio transmitters, which require anesthesia and surgery. In this study, I sought to find an effective method of applying external transmitters that would 1) remain intact without abrading skin and 2) allow for unimpeded movement in the field. To these ends, I designed a harness that held Advanced Telemetry Supplies A1015 Series transmitters (0.55g). The Velcro® harness was tested to fit just posteriorly to a salamanders front legs with a transmitter attached dorsally. Five outfitted Spotted Salamanders were held overnight as well as in the field for 30 minutes minimum before release. Four of the five transmitters were tracked and retrieved over 11 days, with movements ranging from 86ft to 173ft. This method holds promise over previously used techniques for short term tracking of salamanders due to its non-invasive nature, quick application, and lightweight quality.

Surveying beaver presence, activity, and conflict in the Otter Creek/Cromwell watersheds

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After significant discussion about beaver activity by park managers following the 2017-2018 winter, the wildlife division began a preliminary study of the Cromwell Brook, Otter Creek, and Canon Brook watersheds to understand beaver population densities and activity levels in that region. The intention of this study was to solidify survey methods and complete a survey of one of the known areas of the park with significant beaver presence. Technicians explored water bodies and wetlands, both current and historic, to map beaver foraging and dam- and lodge-building activities on the landscape. Drawing from the beaver surveys conducted in 1998 and 2009, the information collected through this census may give the park more information about beaver habitat preference, movement over time, and the scale of their impact on the landscape.

Whither Schoodic? Monitoring visitor numbers and activities in a time of change

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The development of the Schoodic Woods campground and visitor center in 2015 resulted in significant changes for visitation in the Schoodic Peninsula. The new infrastructure included a 100 car parking lot, a 97 site campground, 7 miles of bike paths, and 5 miles of hiking trails to park facilities. Since the construction of these sites, vehicle and bicycle traffic data has been collected to better gauge visitor use patterns and volumes. Visitation trends from 2015-2018 will be discussed, as well as possible trends over the next 5 years.

Mapping dikes and faults on the Schoodic Peninsula, Acadia National Park

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Digital mapping of dikes and faults that cut the Devonian Gouldsboro granite on the Schoodic Peninsula, Acadia National Park was conducted by undergraduate student survey teams from the University of Southern Maine, 2013-2018. Their work provides a unique detailed perspective of the long famous dike intrusions as well as the new Schoodic Point Fault Zone. RTK GPS and total stations were used to delineate the geometry of fracturing and faulting associated with dike intrusion and the early stage fault zone development preserved within these exposures. Mapping has now covered ~150 separate dike intrusions, from less than 1 cm to over 10 meters in width, from Pond Island on the west, across Big Moose Island and Schoodic Point, and Little Moose Island to the Blueberry Hill Pullout on the east. Mapped dikes include early pluton-related felsic aplite and rhyolite porphyry dikes as well as the more common mafic basalt and diabase dikes. The distinction between older pluton-related and younger rift-related mafic dikes is still not clear at this time. Dike orientations are dominantly NE-SW with additional NNE-SSW, and generally younger NW-SE and NNW-SSE oriented dike sets. Lengthening the mapped dikes in their strike directions gives a more realistic view of how these myriad of dikes have sliced across the Schoodic Peninsula. In addition, over 900 short small-scale fault segments have been surveyed in a NW-SE zone over 400 m in length

across the western side of Schoodic Point. Faulting was initiated prior to nearly all of the dike intrusions. Faults are marked by patches of coarse breccias, thin zones of cataclasite, sidewall ripout geometries and rare horizontal striations. Most offsets of the earliest aplite dikes and other earlier faults are in the cm to 10s of cm range with possible meter scale displacements for larger zones where smaller fault segments have merged together. Projected connections between mapped fault sections reveal several left-stepping en echelon right-lateral strike-slip segments that are frozen at an early stage in the process of linkage to a through-going fault zone. Lengthening of fault segments that would have occurred with further displacement suggests what a mature through-going fault geometry would look like for a more developed Schoodic Point Fault Zone.

How has the development of Schoodic Woods changed the ecosystem services provided by Acadia National Park?

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Ecosystem services are the economic benefits provided to humans for free by ecosystems, and they provide a framework for managing public lands as a socio-ecological system. Ecosystem services allow managers to ask questions such as 'does developing public land and enhancing its use for tourism ultimately create benefits to its stakeholders that outweigh the impacts of the development itself?' Understanding how new developments in public lands impact the full set of market- and non-market ecosystem services will allow for strategic growth that preserves ecosystem services such as biodiversity and carbon storage, while optimizing tourist revenue and benefitting local businesses.

In 2015, ANP opened the Schoodic Woods Campground which hosts 97 campsites, accompanied by 7 miles of new gravel bicycle paths, 5 miles of hiking trails, a visitor center, and parking for 100 cars. These developments have increased visitor access to Schoodic Peninsula, increasing the valuation for recreational experiences. However, increased development may negatively influence other ecosystem services such as biodiversity and carbon storage. With this project, we estimated the valuation of ecosystem services provided by Schoodic Peninsula focusing on its three greatest contributors: 1) biodiversity, 2) recreation and tourism, and 3) carbon storage, and estimated how these valuations have changed since the developments of the Schoodic Woods Campground.

This research was conducted by the 21 undergraduates in UMaine's EES 217 class between September 28-30, 2018. Over the course of just 48 hours, the students collected and analyzed data in teams, as well as presented the results of their research to the public. While in residence at the Schoodic Institute, they used the living lab of Acadia National Park to investigate a question of importance to local stakeholders. This is what they found:

Mobile mapping: A new tool for eelgrass monitoring around Mount Desert Island

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The Community Lab at MDI Biological Laboratory implemented new tools to map eelgrass with updated and improved mapping systems in the 2018 field season. The new mobile GIS (Geographic Information Systems) solution that was trialed utilizes Bluetooth technology and a Trimble R1 GNSS receiver to capture higher accuracy geospatial data that saved Community Lab staff time in the field and with post-processing work, all while improving data accuracy and streamlining data collection and map dissemination.
This new technology builds on a decade of work by staff, students, and volunteers who began mapping eelgrass (Zostera marina) populations around Mount Desert Island (MDI), Maine as part of the work of the Community Lab to monitor, study, and conserve these essential habitats, with a focus on nine study sites around MDI. Eelgrass was declining across the state and knowing where populations were and how they were changing was an important factor in conservation efforts. The Department of Marine Resources and Maine Office of GIS previously mapped and published two state-wide datasets of eelgrass locations, one in 1997 and one in 2010. Each dataset took multiple years to compile and complete. For example, in the 2010 dataset, the Mount Desert Island region was mapped in 2008, and that was the last formal state-led assessment of eelgrass in the region. Aside from anecdotal observations, there have not been formalized calculations of the health of the remaining eelgrass populations in the region since then. Recognizing the need to maximize efficiency and utilize advancing technologies, the Community Lab has begun using new mobile tools to map eelgrass with updated and improved mapping systems, resulting in highly accurate maps of eelgrass in several of the 9 study sites. Continued mapping will result in an archive of accurate maps for reference by future generations of eelgrass researchers in Maine.

Population biology of rockweed (Ascophyllum nodosum) in Frenchman Bay: Assessment of a commercially targeted and ecologically important species

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Rockweed or knotted wrack, Ascophyllum nodosum, is an important canopy-forming species in the mid-intertidal along rocky shores in New England. It also comprises 90% of Maine's 19 million-dollar seaweed industry. Rockweed fishery limits in Maine include limiting the total rockweed biomass that can be removed in an area, and requiring a minimum cutting height of 16 inches. In order to manage rockweed harvest, policymakers must carefully consider the alga's ecological and economic roles. To understand the rockweed resources of Frenchman Bay we collected data at sixteen sites around the bay, examining the extent of the rockweed bed; the size, weight, and age of plants; and the role that rockweed plays in influencing the temperature and light levels in the rocky intertidal. Preliminary data suggest that growth rates are largely consistent across sites, that larger alga are found in the mid and lower Bay, and that protected and exposed sites yield different biomass data. Rockweed has profound effects on the physical environment on the mid-intertidal, and the effects of harvest on these physical factors and the biological community are not well known. We have begun a set of experiments in Frenchman Bay, comparing areas of simulated harvest to control areas without harvest to try to understand how this species affects light and temperature intensity and community structure in the intertidal.

The Norway maple forest in Acadia National Park: Initial response to management

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National Park Service, Acadia National Park, Bar Harbor, Maine

The non-native tree, Norway maple (Acer platanoides) has been identified as a priority invasive plant for management in Acadia National Park. Starting in 2018, Acadias Exotic Plant Management Team began treatment in several Norway maple stands. This presented a unique opportunity for us to research the forest changes associated with management activities through the establishment of Norway maple long term monitoring forest plots. This research will guide future management strategies of Norway maple, and enables staff to watch for the incursion of other exotic plants in to these forest systems.

Benthic consumer communities on Gulf of Maine rocky shores: variation with latitude and wave exposure

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The dynamics of rocky intertidal communities throughout the Gulf of Maine are driven by a variety of biotic and abiotic factors. Disentangling the relative impact of consumers across the broad latitudinal extent of the Gulf of Maine is challenging because of natural variation in consumer communities, density, and per capita impact. A first step to understanding the role of consumers, therefore, is to document how consumer diversity and abundance varies across this latitudinal gradient. To do so, we conducted standardized surveys of benthic consumer communities at 10 pairs of wave-exposed and wave-protected sites throughout the Gulf of Maine. On wave-protected shores, total consumer density was highest at mid-latitude sites while on wave-exposed shores, total consumer density was highest at low-latitude sites. Although aggregate consumer density had a relatively simple relationships with latitude, patterns for individual species were more heterogeneous. On wave-protected shores, for instance, the density of smooth periwinkles (Littorina obtusata) declined with latitude, while limpet (Testudinalia testudinalis) density was relatively low at all but one mid-latitude site.. Hence, characterizing the functional roles of individual consumer species may be necessary to understand how top-down processes shape community dynamics at local scales and compare the magnitude of consumer impacts across larger spatial scales. Furthermore, because we also found evidence for large inter-annual variation at some of our sites, we suggest that long-term, large scale studies are necessary to understand the relative importance of top-down and bottom-up processes throughout the Gulf of Maine rocky intertidal.