Senator George J. Mitchell Center
Annual Technical Report
FY 2016

Introduction

Maine is fortunate in being a water-rich state with extensive surface water and groundwater resources. These water resources are essential to the regional economy in terms of energy generation, water supply, agriculture, tourism, industry, and ecosystem services. The state is not without water resource concerns due to flooding, sea-level change, urbanization, stormwater, endangered aquatic species, harsh winters, and natural contaminants such as arsenic in drinking water. The Maine Water Resources Research Institute (WRRI) is the primary independent source of water resources research in the state. Situated in the Senator George J. Mitchell Center for Sustainability Solutions (Mitchell Center), there is an important focus on resource sustainability. It is our mission to facilitate the process to identify, understand, and seek solutions to water resources problems facing Maine citizens using research that is interdisciplinary, stakeholder-engaged, and solutions-driven.

During the FY16 period, the Maine WRRI supported two research projects: 1) Assessing the Vulnerability of Maine's Drinking Water Resources to Extreme Precipitation Events and; 2) Mining in Maine: Exploring Public Perceptions. The Maine WRRI also supported an information transfer project, Vernal Pools for ME, along with additional information transfer activities including the Maine Sustainability and Water Conference, the Northern Maine Children's Water Festival, and a weekly speaker series.

These projects directly supported four graduate students (2 Ph.D., 2 M.S.) and four undergraduate students. The Mining in Maine project also provided an opportunity for 40 undergraduate students and nine graduate students to participate in a service learning project as part of their SFR479 coursework (Environmental Attitudes and Behaviors). Students enrolled in the course supported instrument development, conducted descriptive data analysis for the pilot online survey results, and gave an oral presentation of preliminary findings.

The federally authorized Maine WRRI provides fundamental and essential functions, which would not exist without explicit Congressional re-authorization and appropriations. The federal money that supports the Maine WRRI is highly leveraged with funds provided by other granting agencies, stakeholders, universities, and researchers. In order to identify the most relevant projects for funding, a review committee representing the Mitchell Center, the USGS New England Water Science Center, and other relevant experts assess proposals for relevance to the program's mission, vision and objectives. The WRRI Co-Directors consult with members of the Research Advisory Committee to make final award selections.

Maine WRRI Co-Directors David Hart and John Peckenham also serve as the Director and Associate Director, respectively, of the Mitchell Center, which provides the administrative home for the Maine WRRI and helps increase the breadth and accessibility of water resources research in Maine.

The Mitchell Center was the recipient of a five-year, $20 million NSF RII Track 1 EPSCoR grant from the National Science Foundation. This grant fostered a multi-institutional interdisciplinary research network across the state that continues to create collaborative research opportunities for faculty and students across a wide variety of projects. The Mitchell Center has also received two $6 million, NSF EPSCoR RII Track 2 awards both focused on water resource issues. The first project on Safe Beaches and Shellfish concluded in fall 2016. This project was a collaboration with the University of New Hampshire and four other institutions in Maine and New Hampshire. Several decision-support tools have resulted from this project and are in the final stages of development before being implemented by the Maine Department of Marine Resources and the Maine Healthy Beaches Program. The second Track-2 FEC project, "Strengthening the scientific basis for making decisions about dams: Multi-scale, coupled-systems research on ecological, social, and economic trade-offs," includes five partner institutions, including the University of New Hampshire, University of Rhode Island, and Rhode Island School of Design. The team of 19 faculty, 2 postdoctoral fellows, and 21 graduate students conducts stakeholder-engaged, solutions-driven, interdisciplinary research to examine the

complex tradeoffs associated with alternative management decisions about dams (e.g. relicensing hydropower dams, removing obsolete dams, enhancing fish passage). Drawing from diverse disciplines, the team uses a wide range of innovative tools (e.g. fish survival analysis, production possibility frontiers, dam failure risk assessment, multi-criteria decision analysis, biogeochemical budgets, negotiation simulation, media discourse analysis, participatory systems dynamic modeling) to develop decision-support tools for government, the private sector, and non-governmental organizations.

The Mitchell Center also provides annual seed funding for sustainability projects based on a competitive, peer-reviewed process. One currently funded water resource-linked project engages citizen scientists to evaluate the potential for water quality decline in Maine lakes. The project is conducting a focused study of lakes to develop a lake Vulnerability Index that combines both stakeholder engagement parameters and physical indicators to predict which lakes are more susceptible to deterioration in water quality.

The annual Maine Sustainability & Water Conference was held on March 29, 2016 and continues to be a leading regional event for the water resources community. Research supported by the Maine WRRI is prominently featured at the conference. The 2016 conference attracted over 350 registrants. The number of people and organizations who support and contribute to the conference reflects the importance of water in the state. Through the hard work of Mitchell Center staff, the Conference Steering Committee, and other key supporters, we are able to address the important water issues in Maine and to bring together diverse interest groups. The conference schedule provides ample time for networking; an important resource for participants working in a large and diverse rural state.

Research Program Introduction

The Maine WRRI supports research, information transfer projects, and seed grants using Section 104b funds. Grants funded under Section 104b deal with important aspects of Maine's highly-valued water resources. Projects are awarded on a competitive basis using a two-stage selection process.

The Maine WRRI issued a call for pre-proposals in spring 2015. Seven pre-proposals were received and were initially reviewed by a panel of relevant experts. Based on this review, four of the investigators were invited to submit full proposals. Shortly after this decision was made, one of the proposals was withdrawn. Three full proposals were received in fall 2015 and were reviewed by the same panel of relevant experts. Reviewers assessed the proposals for relevance to the program’s mission, vision and objectives. WRRI Co-Directors consulted with members of the Research Advisory Committee to make final award decisions. All three of the submitted full proposals (2 research, 1 information transfer) were selected to receive funding.

Preference is given to support innovative projects that focus on the sustainability of Maine’s water resources with research that is interdisciplinary, stakeholder-engaged, and solutions-driven. We also strongly encourage projects that are led by early career faculty, have significant student involvement, and involve researchers at small colleges and universities across the state. Investigators are encouraged to collaborate with state and federal agencies and to seek additional contributions for their projects.

Assessing the Vulnerability of Maine's Drinking Water Resources to Extreme Precipitation Events

Basic Information

Title:	Assessing the Vulnerability of Maine's Drinking Water Resources to Extreme Precipitation Events
Project Number:	2016ME319B
Start Date:	3/1/2016
End Date:	9/30/2017
Funding Source:	104B
Congressional District:	2
Research Category:	Climate and Hydrologic Processes
Focus Category:	Climatological Processes, Ecology, Economics
Descriptors:	None
Principal Investigators:	Jasmine Saros

Publication

1. Warner, K.A., Saros, J.E., and Teisl, M.F. Investigating the ecological response and economic vulnerability of Maine's drinking water resources to extreme precipitation events. Poster presentation. Maine Sustainability and Water Conference, March 30, 2017, Augusta, Maine

USGS 104b (WRRI) Investigator Annual Report

Project Title: Assessing the Vulnerability of Maine's Drinking Water Resources to Extreme Precipitation Events

Principal Investigator: Dr. Jasmine Saros, Climate Change Institute, University of Maine, 137 Sawyer Research Center, Orono, ME, 04469; 207-581-2112; jasmine.saros@maine.edu

Co-Project Investigator: Dr. Mario Teisl, School of Economics, University of Maine, 207 Winslow Hall, Orono, ME, 04469; 207-581-3162; teisl@maine.edu

Graduate Student Investigator: Kathryn Warner

1. Project Summary

Water quality in Maine is being threatened by a rapidly changing climate. The Northeast has experienced a 60-70% increase in extreme precipitation events since 1950 (Madsen and Figdor 2007; Spierre et al. 2010). At present, the extent to which changing precipitation is altering the water quality of Maine's lakes is unclear, making it difficult to determine whether management strategies will need to be modified to sustain drinking water quality.

Lakes are an integral part of Maine's landscapes and communities, and approximately half of the high quality drinking water in Maine comes from 46 lakes across the state. Recent research suggests that average annual concentrations of dissolved organic carbon (DOC) increased in Maine lakes during extreme wet years. In Maine lakes that serve as drinking water sources, scientists and water district managers have identified algal blooms, taste and odor problems, and harmful by-products as some of the problems created by rising DOC concentrations. Currently, however, the extent to which storm events are altering DOC and consequently the biota of Maine's lakes is unclear. Furthermore, little is also known about the economic costs associated with these potential changes in water quality, which pose health threats and expensive remediation strategies.

These extreme precipitation events, and subsequent increases in DOC, pose threats to aquatic habitats and drinking water quality; these changes will increase water treatment costs, and impose other economic losses (lost property tax revenues, lost economic activity) on communities. DOC concentrations are expected to increase in boreal lakes by as much as 65% as a result of climate change effects on terrestrial ecosystems (Larson et al. 2011) therefore understanding the ecological and economic implications are critical. Local stakeholders, particularly water treatment managers, have identified that DOC is a growing concern. For example, in the recent past, algal blooms have occurred in Chases Pond in York, ME following extreme rain events. The York Water District speculates that these blooms are a result of increased DOC from rain events. Additional water districts have also observed increased algae and have expressed concern about changes in DOC due to the relationship with disinfection by-products. The participating water utilities in this study do not have data to identify how storms are influencing the lakes and welcome help in addressing the issue of extreme rain events and

DOC. A better understanding of the effects of extreme precipitation events on Maine lakes is important as impaired drinking water quality, weakened aquatic habitats, and a loss of lake aesthetics may have significant negative impacts not only on the lakes, but communities relying on these lakes for drinking water, recreation, and tourism. Research conducted for this project, and the collaborations with local stakeholders has identified how a subset of Maine lakes are responding to storm events and what that may mean for the quality of the water and subsequent water treatment costs. This research has allowed us to assess the vulnerability of drinking water sources to extreme precipitation events as well as evaluate future vulnerability of additional Maine drinking water sources.

2. Problem and Research Objectives

Increasing DOC and its subsequent biological effects have important implications for drinking water quality. Drinking water utilities are growing increasingly concerned as increases in DOC correlate to increases in disinfection by-products (DBPs) (Van Leeuwen et al. 2005; Uyak and Toroz 2007). DBPs as well as increased levels of complexed heavy metals and adsorbed organic pollutants are all problems created by a rise in DOC concentrations in drinking water (Matilainen 2010). DOC also provides carbon sources to mixotrophic algae, including chrysophytes. Some chrysophyte algal blooms contribute to taste and odor problems in drinking water sources (Nicholls and Gerrath 1985; Nicholls 1995).

Several drinking water utilities have expressed concern over increases in DBPs and are beginning to realize and understand the relationship between changing DOC and DBP concentrations (Zhang et al. 2008; Bond et al. 2014; Ritson et al. 2014). Drinking water resources exempt from filtration are beginning to understand with more frequent storms and subsequent increased DOC in aquatic ecosystems, this exemption from filtration may change and could pose high economic costs. Additionally, alteration to existing filtration could also result in high economic costs. Overall, these costs are not well documented but pose health threats as well as extremely expensive remediation strategies. Since permitting, financing, and construction take time, understanding the pace of this growing threat helps communities make better water management decisions.

The extent to which storm events alter DOC in Maine's lakes is unclear, yet is highly relevant to drinking water treatment. At present, we lack the high temporal resolution data needed to better understand the scope of the problem in Maine. The overall objective of our research was to assess the ecological and economic vulnerability of Maine's drinking water lakes and the communities dependent on these resources to extreme precipitation events and subsequent increases in DOC. Specific objectives included:

1.) quantifying immediate changes in drinking water lakes from extreme precipitation events through measurement of key water quality metrics (DOC quantity, DOC quality, nutrients, algal biomass and community structure) pre- and post-storm;
2.) translating the above changes in water quality into economic losses, primarily the costs to maintain drinking water quality through filtration and/or treatment infrastructure.

3. Methodology

This study focused on a set of 6 lakes that serve as drinking water sources. Standard field and laboratory methods were used to investigate lake water quality. Cost and valuation economics will be used to translate changes in water quality into potential costs to maintain drinking water quality. This project has been and will continue to be conducted by PhD student Kathryn Warner.

Lakes were selected based on morphometric and initial baseline chemical data as well as location, demographics and size of population served. The representative 6 lakes are distributed across the state of Maine to account for differences in climate and precipitation across the state. Variation in lake size and volume across the 6 lakes has allowed us to investigate how water resources of varying sizes respond to storm events and understand how costs may differ. Surrounding landscape, including wetlands, impervious cover and land uses, will also be assessed to identify potentially important land use affecting response to storm events. The surrounding populations are of varying size and economic status. We accounted for water sources that serve a large portion of Maine's population and also sources that might not have as many resources to implement adaptation strategies in order to identify how immediate action may differ and, in the future, allow us to understand long-term implications for different types of communities.

Objective 1: The selected 6 drinking water sources were sampled 24 hours before, 24-48 hours after and 5-7 days after an extreme precipitation event. Raw water was collected from the intake at each water utility to provide consistency, and this is the most relevant for water treatment and implications of extreme storm events on drinking water treatment.

Our measurements focused on DOC concentration and quality as well as phytoplankton community structure, as these are all the variables of primary concern for treatment as well as taste and odor problems. Using filtered water samples, DOC concentrations were analyzed on a Shimadzu TOC analyzer and DOC quality was assessed by measuring dissolved absorbance properties from 200-800 nanometers using a UV-VIS spectrophotometer. Whole water samples were preserved with Lugol's iodine solution for analysis of phytoplankton community. Phytoplankton will be identified to species on a Nikon TS-100 inverted microscope, with a minimum of 200 individuals counted per sample. We also measured nutrient and chlorophyll *a* concentrations to identify nutrient fluxes and changes in algal biomass that may occur as a result of storm events. Nutrients measured include total phosphorus, total nitrogen, nitrate, and ammonium.

To assess relationships between pre- and post-storm events in lakes, data will be analyzed using repeated measures analysis of variance. This will test for significant differences in pre- and post-storm events by evaluating the equality of the means. A significance level of $p < 0.05$ will be used and the Greenhouse-Geiser correction will be used to test for the assumption of sphericity. Post hoc analysis will be conducted using a Bonferroni correction to correct for multiple comparisons.

Objective 2: The primary costs to measure are those aimed at maintaining communities' drinking water quality through the use of filtration or other technologies/approaches. Data collection to identify costs of improving or implementing filtration and/or treatment will follow the Delphi Method; i.e., we will interactively survey water quality experts (e.g., water utility personnel, members of the Maine Water Utilities Association, water quality engineers, firms designing and selling water treatment and filtration systems, and others working on the issue of maintaining drinking water quality) to determine best estimates for appropriate systems to maintain water quality along with the costs of designing, implementing, maintaining, and operating the systems. These surveys will allow us to understand the range of options available to maintain water quality and the respective costs.

Economic losses due to any decline in lake-water-quality will be calculated for each of the 6 lakes by combining information from a regression model (based on a recent meta-analysis of lake water quality studies) with lake and region characteristics. Variables in the model that influence estimated losses include: the starting water quality, the change in water quality, the region, and the size of the lake. Given that the problem (impacts from climate change) and the solution (building and financing infrastructures) have relatively long time horizons we will need to take into account both immediate and long-term losses, requiring the analysis to bring future losses into current dollar terms (i.e., calculate net present value of the stream of losses). As part of the sensitivity analysis we will vary the timeframes, discount rates, and possible population projections.

4. Principal Findings and Significance

A primary sustainability issue related to this research is how to identify, sustain, conserve, and protect Maine's high quality drinking water. This research addresses a relevant piece of this large issue by understanding the ecological and economic implications of climate driven changes on drinking water resources. The solution to this issue is complex in that both the ecological health of the ecosystem must be preserved and the economic impacts must be minimized, while allowing the economy to benefit from the water resources. The results of our research aim to address this solution.

Results evaluating the ecological response of the lakes suggest this research will provide data to assist water districts in future water quality management. The response of the lakes when comparing the different variables to one another (i.e. DOC versus nutrients or chlorophyll *a*) is variable. However when we evaluate the response of each lake to DOC three patterns of response emerge, an immediate spike in DOC concentrations followed by a return to pre-storm levels, a sustained increase in DOC over the sampling period, and no change in DOC. DOC quality metrics are influenced by seasonality and are more variable but, dependent on the DOC quality metric analyzed, illustrate consistent responses to that of DOC concentration. All nutrients evaluated in this study show little to no change over the course of the storm events and chlorophyll *a* responds inconsistently across lakes and storms. This gives us insight into specific water quality changes that we will be able to translate into costs for drinking water utilities. Economic analyses will be conducted over the summer 2017, therefore solutions have not yet been implemented however the relationships formed with stakeholders, primarily water district

managers, will allow for collaborative development and implementation of adaptation and management strategies.

The researcher-stakeholder relationships have been fundamental to the success of this study. Water district managers of the 6 study lakes have been involved in all processes of the research and made it possible to collect a valuable dataset of information from which to evaluate the response of drinking water resources to extreme precipitation events and subsequent increases in DOC. Water district managers collected storm water samples and shipped them to the University of Maine for analysis. This allowed for successful collection of samples from multiple lakes at the same time points, which would not have been possible otherwise.

This research has positioned us well for future funding and partnerships. The data and knowledge acquired from the study itself continue to build on our previous research about DOC and extreme precipitation events. With the information gained from this study we have tangible results that can be used to explain potential implications of climate on drinking water resources with water districts so that they can better understand and prepare for changes that may occur in the future. These same results and current partnerships will allow us to expand our partnerships within the state and from there consider other regions outside of Maine that will experience similar climate changes and work with these new partners to evaluate how their particular water source will respond to extreme storm events.

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Other Documentation

Student support:

Kathryn Warner, Ph.D, Ecology and Environmental Sciences

Participation in this research for Kathryn is directly related to progression and to eventual completion of her dissertation, thus aiding in academic goals as well as career goals post graduation. The nature of this research is applied and engages several stakeholders in order to be successful. This puts Kathryn into a unique networking opportunity where she was able to contact various drinking water utilities to collect lake water samples and explain the research question we are trying to address. This experience has allowed Kathryn to network and pursue applied research that is directly relevant to her career goals. Participation in this research has allowed Kathryn to keep her career options open while pursuing applied research. Kathryn learned to communicate her research to stakeholders and scientists as well as collect a large data set of information from several Maine water resources to be analyzed and communicated back to the relevant water districts. This experience assisted Kathryn in developing these skills necessary to complete this project. Kathryn engaged with several water district managers, which allowed her to modify what important metrics should be measured and would be most relevant and useful to the respective water districts. This improved her perspective on project development and ways to engage stakeholders in scientific research. Working with both an ecologist and economist allowed Kathryn to have multiple outlooks on ways to conduct research and understand various viewpoints when approaching a research problem. This was beneficial when engaging with stakeholders with different knowledge bases, and allowed Kathryn to better explain the research problem and relate ecological data to potential policy and management concerns.

Presentations:

Warner, K.A., Saros, J.E., and Teisl, M.F. Investigating the ecological response and economic vulnerability of Maine's drinking water resources to extreme precipitation events. Maine Sustainability and Water Conference, March 30, 2017, Augusta, Maine.

Warner, K.A., Saros, J.E. Variable responses in lakewater dissolved organic carbon to extreme precipitation events. Association for the Sciences of Limnology and Oceanography Annual Meeting. March 3, 2017, Honolulu, Hawaii.

Warner, K.A., Saros, J.E., Teisl, M.F. Investigating the response of Maine's drinking water resources to extreme precipitation events. 24th Annual Harold W. Borns, Jr. Symposium. April 14-15, 2016, University of Maine, Orono, Maine.

Warner, K.A., Saros, J.E. Investigating the response of Maine's drinking water resources to extreme precipitation events. Maine Sustainability and Water Conference, March 29, 2016, Augusta, Maine.

Mining in Maine: Exploring Public Perceptions

Basic Information

Title:	Mining in Maine: Exploring Public Perceptions
Project Number:	2016ME320B
Start Date:	3/1/2016
End Date:	2/28/2017
Funding Source:	104B
Congressional District:	Second Maine
Research Category:	Social Sciences
Focus Category:	Methods, Recreation, Law, Institutions, and Policy
Descriptors:	None
Principal Investigators:	Sandra De Urioste-Stone, Amanda Albright Olsen, Jean D. MacRae

Publications

1. Morgan, A., De Urioste-Stone, S. (2017, April). Public perceptions of metallic mineral mining in Maine: Research summary report of preliminary results. Report to the Maine Legislature's Joint Standing Committee on Environment and Natural Resources, 29 pages.
2. Morgan, A. (2017, March). Public perceptions of metallic mineral mining in Maine. Poster session presented at the Maine Sustainability and Water Conference, Augusta, Maine

Mining in Maine: Characterization of Public Perceptions
Investigator Report

To

The Maine Water Resources Research Institute

By
Andrew Morgan
Dr. Sandra De Urioste-Stone

2017

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Acknowledgements

The authors would like to acknowledge Dr. John Daigle, Dr. Jean MacRae, Dr. Amanda Olsen, Lydia Horne and students from the spring 2016 environmental attitudes and behaviors course for help with survey design and question development. This study is supported by the National Institutes for Water Resources administered through the Senator George J. Mitchell Center, the Center for Research on Sustainable Forests and the USDA NIFA, McIntire Stennis project ME041504.

About the Authors

Andrew Morgan is a Graduate Research Assistant in the School of Forest Resources at the University of Maine. Born and raised in Maine, he is currently pursuing a MS in ecology and environmental sciences where he focuses on the human dimensions of natural resources. He earned his B.S. in Parks, Recreation and Tourism from the University of Maine. Andrew has been responsible for much of the data collection, study design, analysis, and reporting for this study.

Dr. Sandra De Urioste-Stone is Assistant Professor of Nature-based Tourism in the School of Forest Resources, University of Maine, USA. She earned a BA in ecotourism, MS in resource recreation and tourism, and PhD in natural resources with emphasis on conservation social sciences. Dr. De Urioste-Stone has done extensive work on sustainable tourism, community-based tourism, human dimensions of biodiversity conservation, and sustainable development (including adaptation to global changes, food security, and community-based public health interventions). Her work has included research projects with Maya indigenous groups. Being a Guatemala native, most of her work has been in Latin America. She has had experience working for environmental NGOs and universities in Central America. She has focused extensively on promoting knowledge to action approaches to science.

SECTION A

1. Executive Summary

As new locations for mining activities are sought, some regions with limited recent metallic mineral mining (MMM) history and expertise find themselves grappling with the issues which surround mining activities. Since 2012, Maine found itself in this situation after renewed interest in one of the state's largest metal containing deposits spurred the legislature to revise its MMM laws. Now in 2017, the debate continues demonstrating the importance of a social license to operate. A social license refers to the acceptance or approval of mining operations by local communities and other stakeholders, who can affect the profitability of those operations. This public acceptance or social license to operate, is influenced by risk perceptions, trust in governance structures, and weighing of benefits over costs. With nine mining bills introduced during the 128th legislative session, gaining an understanding of the public's risk perceptions on MMM in the state is both timely and critical.

It is the aim of this study to determine Maine residents' perceptions of metallic mineral mining and the requirements needed for conflict resolution of this current policy debate. Researchers have sought to identify major debate themes utilizing publicly available secondary data including public hearing testimonies and newspaper articles between 2012 and 2017. With additional funding, a mail survey which was not part of the proposal was also implemented to gather opinions from a wider audience of Maine residents. A total of 501 residents from across the state responded to this survey. WRRI funding was used to conduct an online survey which, due to a small response rate, was utilized as a pilot to inform the development of the larger mail survey. This report presents results from the larger mail survey.

Preliminary analysis of the secondary data identified several topics that have been prominent concerns for stakeholders. These topics include: water quality, mining on public lands, human and wildlife health, financial assurance, site closure and reclamation, potential impacts to existing industries, mistrust in mining organizations and also the state government. Survey participants expressed similar concerns. The majority of survey participants believed that human health (53%), fish and wildlife health (69%), and water quality (67%) would decrease if a metallic mineral mine were developed near their community. Likewise, the majority of survey participants (64%) agreed that a metallic mineral mine would be harmful to the local natural environment and over half (54%) of participants believed nature based tourism would decrease as a result of a potential local mine..

Over three quarters (78%) believed employment opportunities would increase. However, the majority of survey participants (63%) agreed that the negative impacts of MMM outweighed the benefits. These results have recently been reported to the Joint Standing Committee on Environment and Natural Resources to aid in their deliberations on the many mining bills proposed during the current legislative session.

2. Problem and Research Objectives

The prospect of rising metal prices driven by growing world populations and affluence, and the existence of several rich deposits have renewed interest in mining in Maine and spurred revision of the strict regulations governing the establishment of mining operations. While there are currently no operational metal mines in the state, there were active mines in the late 1800s and the mid 1960-70s in coastal areas (Lepage, Foley, & Thompson, 2015). Volcanogenic massive sulfide deposits are distributed throughout the state (Figure 1) and are associated with volcanic belts stretching from the New Hampshire-Quebec border, through northern Maine and into New Brunswick, and along the coast. Geologically and chemically similar deposits have been successfully mined in both New Brunswick and Vermont. These deposits are attractive as mines because the hydrothermal processes involved in their formation concentrate valuable ore minerals including copper, zinc, lead, gold, and silver; however, they are also very high in sulfur and iron as well as heavy metals that can be damaging to the environment and human health.

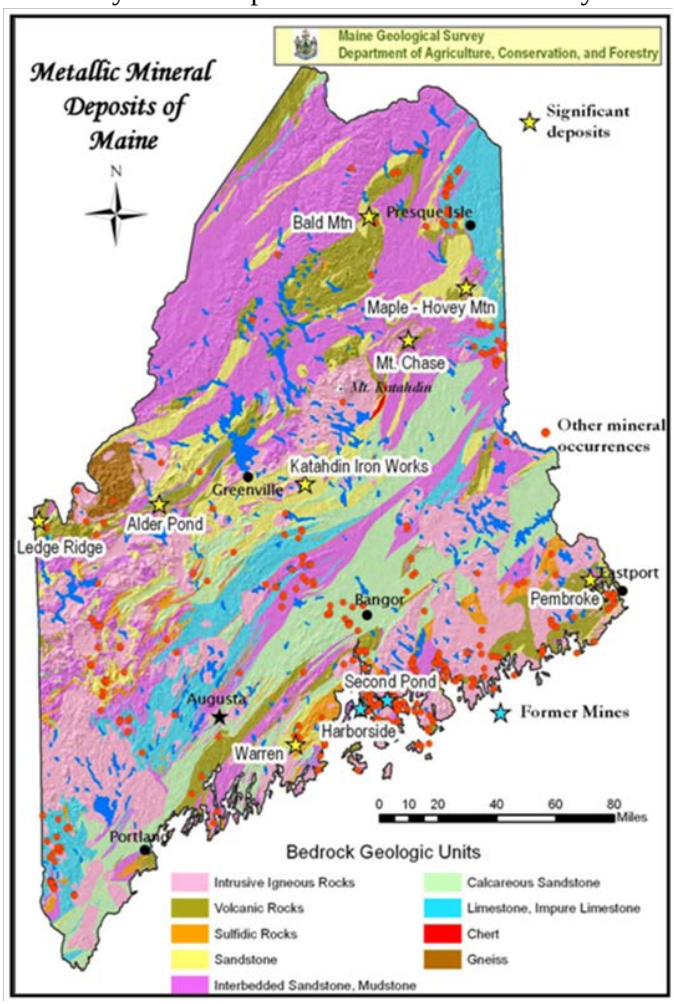

Figure 1. Historic metals mines and metal deposits in Maine. Yellow stars denote massive sulfide deposits with mining potential and blue stars represent former metals mines (Maine Geologic Survey, 2013).

Mining uncovers and increases the reactive surface area of sulfide minerals and increases their exposure to water and oxygen. These conditions enable oxidation of sulfide minerals, which generates acidity and causes acid mine drainage (AMD). Microorganisms that generate energy for growth by catalyzing the oxidation reactions greatly increase the rate of acid production. The acid accelerates metal dissolution from the waste rock and tailings, producing a leachate that can be extremely high in dissolved metals and environmental toxicity. It has been estimated that 20,000 km of streams and rivers in the US have been degraded by AMD (Skousen, Sexstone, & Ziemkiewicz, 2000). Two former metal mining sites in Maine—the Callahan Superfund site on Cape Rosier, and the Kerramerican mine in Blue Hill—have both produced acid and high metal concentrations in surrounding surface waters and sediments (Marvinney & Berry, 2015) (Figure 1). While remediation has been undertaken at both sites, they still pose a risk, and thus require ongoing monitoring. Modern mining seeks to minimize the impact to surrounding environments by preventing the establishment of AMD-causing microbes through limitation of mineral exposure to water and/or oxygen. Treatment may also be required to contain or immobilize any

metal-contaminated acid leachate that is generated (Skousen et al., 2000); however these processes can continue for decades and even centuries requiring perpetual treatment and containment.

Maine has not had an active metal mining operation since the mid-1970s in part due to strict environmental regulations. Over the past several years, lawmakers have sought to rewrite Maine's mining legislation to allow for increased mining. Particular interest has focused on Bald Mountain, a massive sulfide deposit in Aroostook County, which has been explored as a possible mining deposit for nearly forty years. As the process moves forward, it is essential to consider place-based perceptions of residents, who are likely to be affected by the risks and opportunities resulting from mining activities.

With no mining for 40 years, there is little local expertise, public familiarity or interest in mining-related issues in the state. The issue is complicated by differences in relevant temporal and spatial scales: the benefits accrue to companies and workers at the mine in the shorter term. The risks to the aquatic and forest ecosystems, and the citizens who rely on these resources to support their livelihoods, health, and recreational activities, will extend over a greater distance and longer time. A lack of public engagement could lead to development and implementation of legislation that is drafted primarily with input from a small set of stakeholder groups—interested companies—and with limited input from citizens or place-based data on potential values and risks. Given the important ramifications of legislative changes, we believe place-specific information and expertise are needed. This study therefore sought to characterize residents' knowledge, attitudes, and potential behaviors towards mining.

2.1 Study purpose

It is the aim of this study to determine Maine residents' perceptions of metallic mineral mining and the requirements needed for conflict resolution of a current policy debate.

2.2 Study Objectives

The objectives of this study are to (1) Track the evolution of the mining policy debate since 2012, (2) Better understand the perceptions and acceptance levels of Maine residents, (3) Determine the barriers that have prevented approval of the rule revisions and the conditions required for approval, (4) Provide information to policy makers to aid in their deliberations concerning metallic mineral mining in Maine.

In order to achieve these objectives we analyzed secondary data and conducted a survey to measure Maine residents' perceptions of likely environmental, socio-cultural, and economic risks and opportunities that could result from increasing mining activities, how those may impact their quality of place, and potential behaviors.

Results of the survey have been provided to the legislature to inform decision making. These results together will also form the basis for additional grant proposals to fund a larger-scale project, which will lead to development of local expertise in both faculty and students.

3. Methodology

3.1 Study Design

Data has been collected between January 2016 and March 2017 using a mixed methods approach, with both qualitative and quantitative research components.

Component 1—Content Analysis of Secondary Data: Throughout the research qualitative data was collected which included public hearing testimonies and newspaper articles. Testimonies were acquired through the Maine legislature and Board of Environmental Protection websites. News articles are predominantly from the Bangor Daily News and the Portland Press Herald. A qualitative content analysis was conducted on these testimonies and news articles using NVivo 11, a software that assists in such qualitative analysis.

Component 2—Resident mail-survey: Survey instruments were mailed to Maine residents beginning in July 2016. Up to two replacement questionnaires were sent and up to one postcard reminder to those who did not respond by set dates. Responses were recorded and analyzed in IBM's Statistical Package for the Social Sciences (SPSS).

3.1.1. Survey Sampling

Resident mailing addresses were obtained through InfoUSA and were selected using a stratified random sampling design. Based upon the 10 known significant metallic deposits in Maine, four strata were created for mailing the questionnaire (Fig. 1). The sample consisted of 2,573 valid addresses. Similar to Zhang and Moffat (2015) this study oversampled strata 1 and 2 with 830 and 839 addresses respectively to insure adequate number of responses from areas which have the greatest potential to be directly influenced by mining activities.

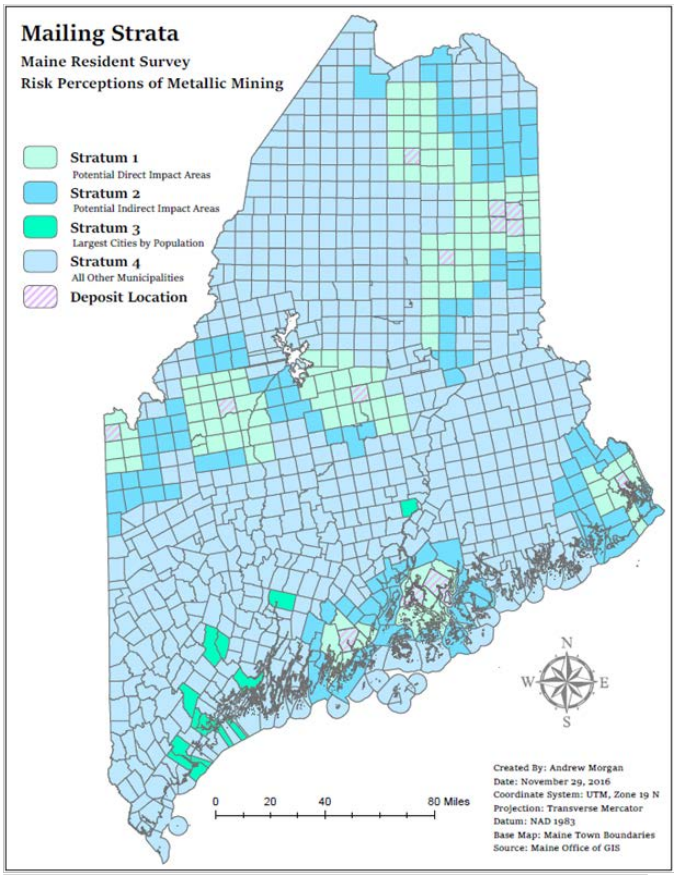

Figure 2. Map of sampling strata for mail survey of Maine residents.

Stratum one consists of those communities that are in closest proximity to the deposits or that have the potential to be most directly influenced if a mine were developed. Potential negative impacts from groundwater, air, and noise pollution as well as positive economic impacts could affect communities in any direction. Potential surface water pollution can be transported farther distances by rivers and streams. A deposit's proximity to waterways and the size of those waterways determine the distance of the direct impact.

Similarly, stratum two also revolves around the deposits but with fewer direct impacts. The largest determinants were both potential surface water pollution on larger waterways and being within a commutable distance (~1 hour) from the potential mine site. Stratum three is based upon the largest metropolitan communities in the state. Stratum four is the rest of Maine.

3.1.2. Questionnaire Design and Implementation

The mail questionnaire was designed using an adapted version of van der Linden's (2015) socio-cultural risk perceptions model. Our questionnaire utilizes knowledge, experience, socio-cultural, trust and socio-demographic constructs to determine risk perceptions which in turn influences acceptance levels. For more information on the theoretical framework please see Appendix A. The surveying period began July 2016 and ended in March 2017. The questionnaires were sent to the addresses determined in the sampling design with a cover letter and a prepaid return envelope. One adult (whoever had the most recent birthday) from each address was asked in the cover letter if they would be willing to participate and instructions on how to do so.

3.2. Quality Control

3.2.1. Pre-Testing

Funding from WRRI was originally used for an online survey developed and implemented as part of an environmental attitudes and behaviors course in the School of Forest Resources during the spring 2016 semester. Due to the very small response rate we utilized the online survey as a pilot to inform the implementation of a mail survey. Based upon the results of this pilot survey changes were made to make questions easier to understand and ensure we received an adequate response rate before implementing the mail survey.

3.2.2. Response Rate

The response rate for the mail survey was 19.5% (501 out of 2,573). We do not have phone contact information of participants so we are unable to follow up with any of those who did not respond to our survey. However, responses from those who responded after the final contact have been shown to be similar to non-respondents (Armstrong & Overton, 1977). Therefore, we will be comparing responses between those who responded to the mail survey after the first mailing with those who responded after the final contact.

4. Results

4.1. Qualitative Data

Over the past five years only introduced bills (LD 1302, LD 1324, LD 1059, and the original version of LD 750) that sought to strengthen the 2012 Metallic Mineral Mining Law received more support than opposition (Fig. 3). In Figure 4, the positions of all the testimonies and written comments given to the Board of Environmental Protection on the most recent proposed Chapter 200 rules are displayed. The opposition was overwhelmingly dominant with 486 opposed while only three supported and two testified neither for nor against the rules. No testimonies from the most recent public hearing held on March 20, 2017 have been analyzed.

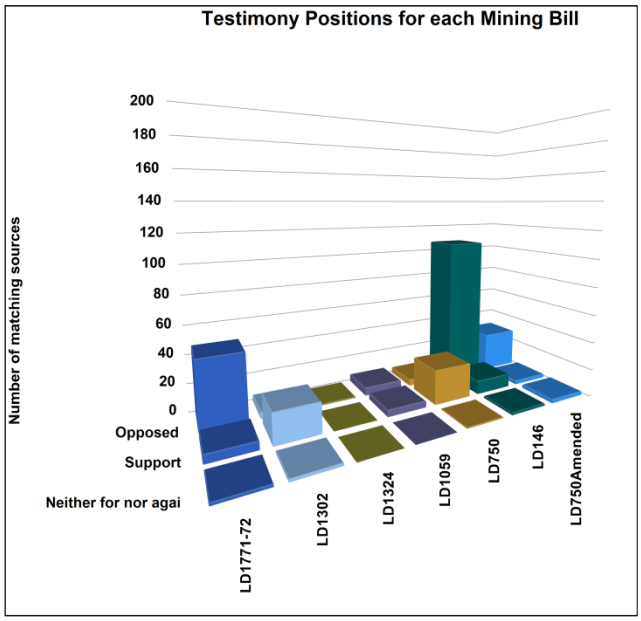

Figure 3. Positions of testimonies for several bills related to metallic mineral mining.

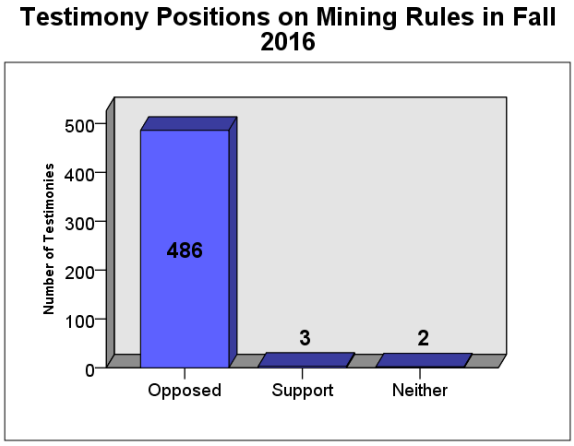

Figure 4. Position of testimonies and written comments on proposed Chapter 200 rules submitted to BEP during Fall 2016.

Figure 5 displays the most frequent words within all the testimonies and news articles. The size of the word indicates its prevalence. Several major areas have been dominant and most consistent over time as barriers to rule approval. These barriers are displayed in Table 1.

Figure 5. Word cloud showing the most frequently used words in testimonies and news articles from 2012 through 2016.

Table 1. Topics identified as major barriers that have prevented approval of past mining rules.

Major Barrier Topics
▪ Water quality
▪ Mining on public lands
▪ Human & wildlife health
▪ Financial assurances
▪ Site closure & reclamation
▪ Potential impacts to existing industries
▪ Mistrust in mining organizations
▪ Mistrust in state governement

It appears much of the opposition came from views that the mining risks are too high and the rules are inadequate to reduce that risk. Many believe the policy makers have pushed for weaker rules while the testimonies have been disproportionally calling for stronger ones (see Table 2). However, some, especially DEP have argued that the rules can't be any stronger because they have to fit within the framework of the 2012 statute. This has displayed the problem caused by the rapid passage of a law

concerning an unfamiliar topic and without a lot of public input. During the public hearing held by BEP on the proposed rules in September 2016, Melanie Loyzim, deputy commissioner of DEP, stated:

> What we're hearing today is a great deal of opposition to the law. Unfortunately, we do not have the power to change the law. What we have to do is change the rule.

The DEP communications director has added these comments:

> [The DEP] cannot exceed or act contrary to its rulemaking authority and other state laws... department does not have the ability to fully address these concerns without statutory changes by the Legislature."

In addition to the misgivings about the adequacy of the mining rules, many who have testified express high risk because of their experience with living near Maine's two superfund sites.

> I live in the Blue Hill Peninsula area, the site of 2 Super Fund sites, one in Blue Hill, the Kerramerican Mine and the other, the Callahan Mine, in Brooksville... These two sites illustrate the devastating history of mineral mining (Female, LD1772, 2014).

But supporters say that this is not a reasonable comparison because of the age of these sites.

> This reputation stems for the most part from unregulated mining which pre-dated the EPA or the DEP but the legacy of fear about mining persists and in the present case, is being exaggerated by those individuals and groups who clearly are anti-mining, at least for Maine (Male, LD1772, 2014).

Frustration has mounted as the interval lengthens between the passage of the 2012 law and the approval of the rules. It is not just opponents but companies with mining interests also share the frustration.

> The fact that the State has passed a new metallic mining law, however failed to adopt pertinent rules in essence creates a moratorium, or at the least the basis for a lengthy litigation battle if someone were to apply for a permit (Aroostook Resources, LD 750, 2015).

Table 2. The number of references on perceptions of inadequacy of the mining rules.

Category	Codes	2012	2013	2014	2015	2016
Inadequate Rules	Weak mining rules	0	2	4	33	517
			"2,000 people signed a petition submitted by Maine Conservation Voters expressing opposition to weak mining rules" (BDN, 2013).	"Despite overwhelming public comment in favor of stronger and more protective rules...the overall direction of these changes is to make the rules substantially less protective" (TU, LD1772, 2014).	"To risk our precious natural resources with weak mining rules is unacceptable" (Female, LD 146, 2015).	"I urge you to reject the latest version of DEP's weak mining rules. I am very concerned that these weak rules would allow mining corporations to pollute our water and harm our woods and wildlife for centuries" (111 written comments used this phrase).
	Need protective rules	0	1	8	17	6
			"a region where economic development, whether industrial or recreational must be subject to stringent rules" (Male, LD 1059, 2013).	"I am not opposed to the extraction of metallic minerals in Maine, but am committed to rigorous oversight, with tough, clear and effective rules that are vigorously enforced" (Male, LD1772, 2014).	"We need very protective and clear rules that will help prevent the type of problems that have plagued communities, taxpayers and the environment near mines across the country. These rules are neither protective nor clear" (NRCM, LD 146, 2015).	"I hope you will do everything in your power to establish strong mining rules that will protect Maine's amazing water resources. The proposed rules are not strong enough" (Female, Ch 200, 2016)..
	Lack of experts	1	0	1	0	1
		"the task of designing rules now that really will be adequate for the future will take more expertise and time than this committee has available in these few weeks" (Rep Chapman, LD 1853, 2012).		"the current language has no scientific basis and provides no clear guidance for how a mining company might be expected to develop and defend its monitoring plan" (Male, LD 1772, 2014).		"demand that the statute be fixed under expert guidance of a multi disicplinary expert panel free of all political, agency and mining lobby influences" (Bowker Associates, Ch 200, 2016).

Others have expressed opposition partly due to the mistrust they have in the state government (see Table 3). This mistrust has stemmed from the involvement of J.D. Irving in the initial push for a new mining law and their relationship with the state legislator who sponsored the bill.

> These rules are the result of JD Irving's stated desire to mine at Bald Mountain. The sense of urgency that has surrounded this rulemaking over the course of the past two years — the sense that Maine needs new mining rules is also a JD Irving creation (NRCM, LD 1772, 2014).

Additional sources of mistrust include the rapidity of the passage of the 2012 law, little initial public input, suspected non-compliance with Maine's Administrative Procedures Act, resubmitting rules that were alleged to be the same as the rules that were rejected the year before, and the appearance of weakening rules while public input was calling for stronger ones.

Table 3. References about mistrust in the state government.

Category	Codes	2012	2013	2014	2015	2016
Mistrust in State Gov't	Irresponsible mining rules	0	2	0	4	114
			"Maine Legislature in 2012 rushed through a law requiring the DEP to write new, less-stringent mining rules for the whole state" (The Boston Phoenix, 2013).		"It is clear that the overall intent of these metallic mining rules is to relax regulations on the metallic minerals mining industry" (Male, LD146, 2015).	"The past two years, thousands of citizens and many local organizations said "NO" ...and defeated these irresponsible mining rules" (111 written comments used this phrase).
	LePage admin	1	0	0	0	114
		"LePage and his cronies want to say 'screw clean water, we need ten jobs for ten years'" (Online comment, 2012).				"For the third year in a row, the LePage Administration is pushing weak mining rules that attack on our clean water and land" (111 written comments used this phrase).
	MAPA non-compliance	0	1	9	13	2
			"In light of the improprieties on the part of Maine DEP, and considering the devastating damage that would be allowed under the permissive rules proposed by the agency, I contend that the mining law enacted in 2012 must be repealed" (BDN, 2013).	"The Department of Environmental Protection... did not follow administrative procedural rules that require a ten-day public comment period" (Rep Chapman, LD1772, 2014).	"I understand that LD 750 ...demands that the rejected metallic mining rules comply with Maine's Administrative Procedures Act" (Resident, LD 750, 2015).	"MAPA specifically requires that DEP affirmatively seek best knowledge and science applicable to all rulemaking, even routine technical rules. DEP has not satisfied that standard for many many years now. It is not meeting this standard in this reckless rule" (Bowker Associates, Ch 200, 2016).
	Resubmitting rejected rules	0	0	0	12	4
					I speak in opposition to L.D. I46, a bill that contains verbatim the same mining rules that were rejected by the legislature last year (Female, LD 146, 2015).	I am totally confounded by your recent attempts to resurrect rule making (Male, Ch 200, 2016).

4.2. Resident Mail Survey

A total of 501 individuals responded to the mail survey. The mail survey was voluntary therefore participants could skip questions if they desired. Non-responses for each question were not calculated in percentage totals. The following results give the exact number of responses (N) for each question. These results reflect descriptive results only.

4.2.1. Demographics (residence, place of origin, gender, age, education)

General demographic characteristics from respondents are presented in Table 2 along with comparisons with census data and Maine 2016 voter registration data. Just over half of the respondents were female (51.9%) which is nearly identical to 2010 Census data. The mean age of all participants was 58.3 (as a requirement, all participants were 18 years or older). A higher percentage (52.9%) of participants have a Bachelor's degree or higher than the overall Maine population (28.4%). Participants' political affiliation mirrored very closely to that of the Maine population with 29.9% Democrat, 26.7% Republican, 37% Independent, and 6.4% other.

Table 4. Demographic characteristics of residents who responded to the mail survey. N=501.

Demographic Characteristics	N	%	Census Data[1]	ME 2016 Voter Registration[2]
Gender				
Male	235	48.1	49	
Female	254	51.9	51	
Age in years				
Mean	58.3 yrs			
Education				
Less than high school	9	1.8	8.7	
High school	75	15.3	33.6	
Some college	90	18.4	20.1	
2-year degree	57	11.7	9.3	
Bachelor's degree	147	30.1	18.3	
Master's degree or higher	111	22.8	10.1	
Political Affiliation				
Democrat	140	29.9		32%
Republican	125	26.7		27%
Independent	173	37		36%
Other	30	6.4		5%

Note 1. Gender data from 2010 Census. Education data from 2014 Census estimates. No average age was found for Maine population 18 years and older. All census data obtained from https://www.census.gov/quickfacts.

Note 2. Data obtained from Statewide Registered and Enrolled Data File from http://www.maine.gov/sos/cec/elec/data/. Unenrolled was used to calculate independents. Green and Libertarian were used to calculate other category.

As a result of oversampling strata 1 and 2, over 30% of respondents were residents in Aroostook (18%) or Hancock (15%) counties (Fig. 5). Cumberland County was third with 13% while Oxford and Sagadahoc counties only comprised 1% each.

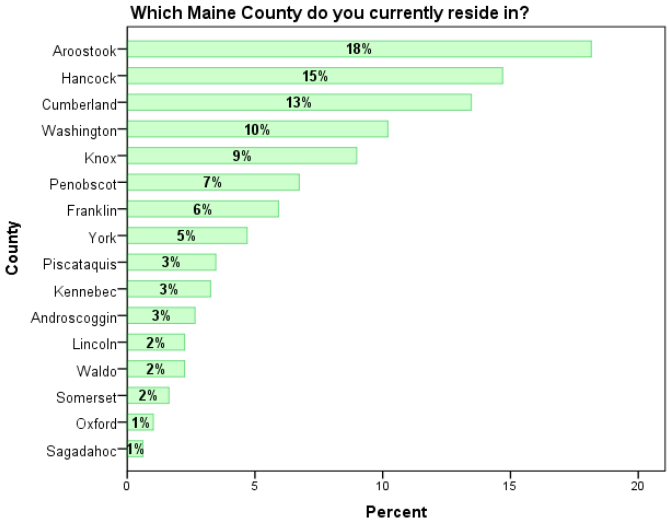

Figure 6. Percentage of respondents from each Maine county. N=501.

4.2.2. Profile (Experience, Knowledge, and Community)

The questionnaire asked questions related to a participants experience with any type of mining, knowledge about metallic mineral mining in Maine, and questions about their own community. Table 3 displays the results from a few experience and knowledge questions. The vast majority (83%) had no personal or family experience with any type of mining. Approximately 40% incorrectly thought that there were currently active metal mines in the state while nearly two thirds (63.5%) had not heard about the MMM discussion occurring in the state prior to participating in the survey. Of those that did have prior knowledge, three quarters (74%) got their information from newspapers and over two thirds (68%) from local TV/radio news outlets.

Table 5. Answers to experience and knowledge related questions.

Experience & Knowledge Survey Questions	N	%
Q1. Experience with any type of mining?	477	Yes = 17 No = 83
Q2. Currently active MMM in ME?	403	Yes = 39.2 No = 52.1 I Don't Know = 8.7
Q4. Prior knowledge of MMM discussion?	485	Yes = 36.5 No = 63.5

Figue 6 shows results for the question that asked a participant's level of agreement to the statement "I am concerned about my community's ability to attract young people." A quarter (26%) strongly agreed with this statement. In all, 75% had some level of agreement to this statement. Nearly identical results are displayed in Figure 7 with 76% expressing some level of agreement to the statement "limited job opportunities have caused the departure of people who lived in my community."

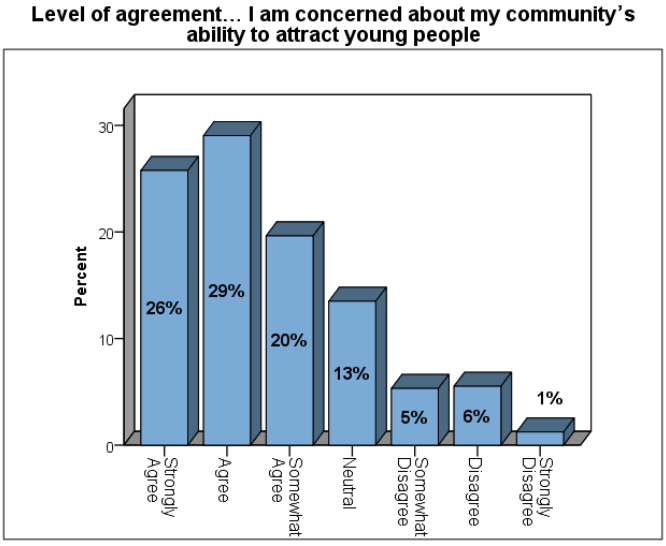

Figure 7. Respondents' level of agreement with the statement "I am concerned about my community's ability to attract young people." N=489.

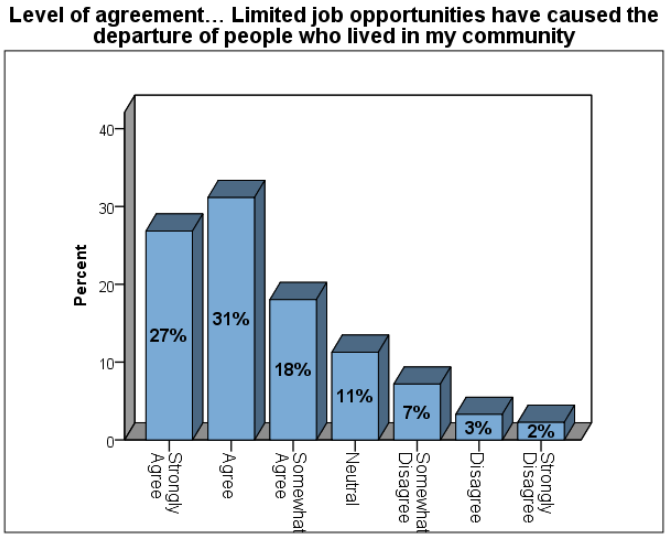

Figure 8. Respondents' level of agreement with the statement "Limited job opportunities have caused the departure of people who live in my community." N=488.

For the statement " people in my community are typically supportive of resource extraction jobs", 7% strongly agreed, 48% either agreed or somewhat agreed (Fig. 8). Even more had some form of agreement (87%) that 'people in my community are typically supportive of jobs in the tourism industry (Fig. 9).

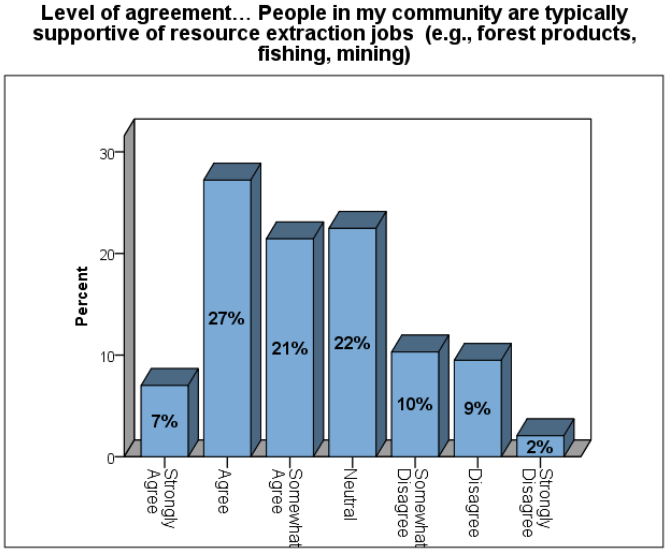

Figure 9. Respondents' level of agreement with the statement "People in my community are typically supportive of resource extraction jobs." N=485.

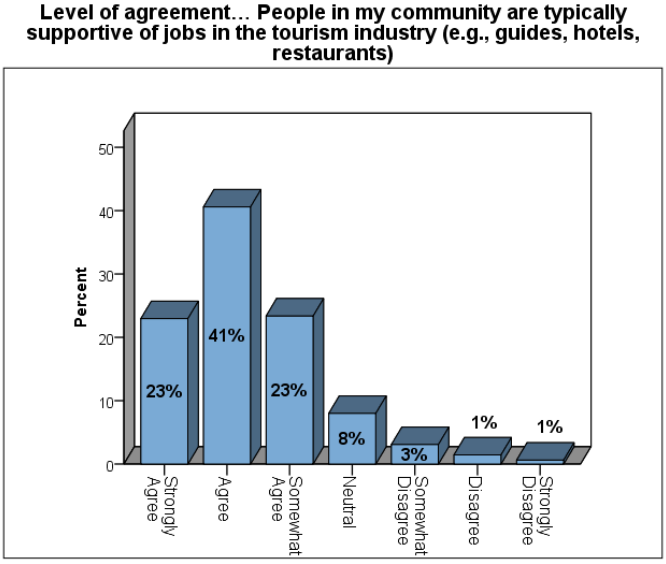

Figure 10. Respondents' level of agreement with the statement "People in my community are typically supportive of jobs in the tourism industry." N=488.

4.2.3. Trust in Information Sources and Strategies

This section displays the results of questions that asked about how much participants trusted different sources for more information on MMM and how much they believed certain strategies would reduce negative environmental impacts of MMM. Trust in newspapers and local news outlets were nearly identical with 52% and 50% having some level of trust (Fig. 10 & 11).

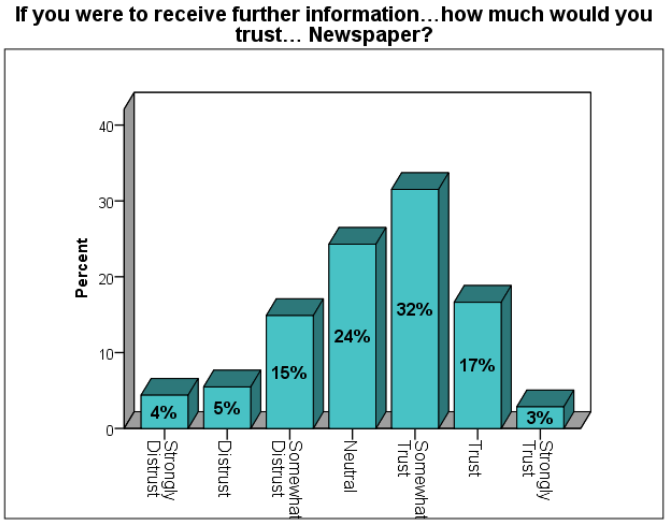

Figure 11. Respondents' level of trust for receiving further information on MMM from newspapers. N=457.

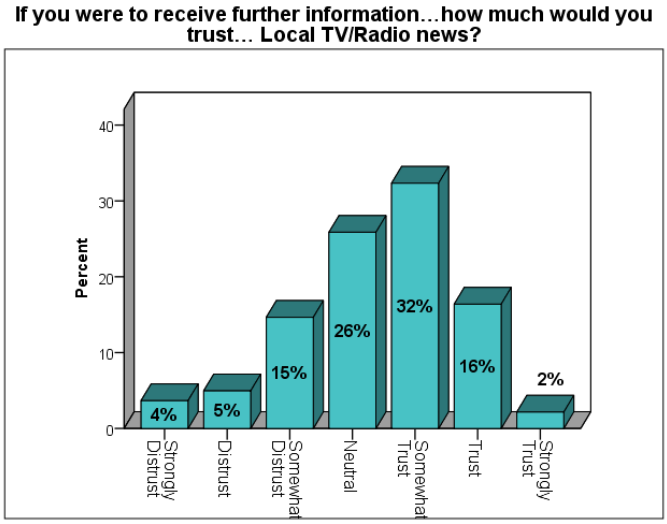

Figure 12. Respondents' level of trust for receiving further information on MMM from local TV/radio news. N=464.

The large majority (84%) had some level of trust in scientists/researchers as information sources (Fig 12). Conversely, 23% somewhat trusted or trusted mining organizations and only 3% expressed strong trust (Fig. 13).

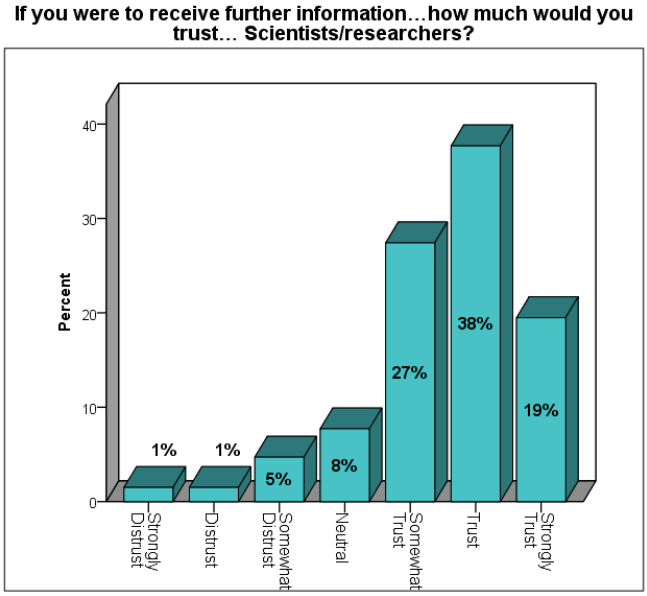

Figure 13. Respondents' level of trust for receiving further information on MMM from scientists/researchers. N=467.

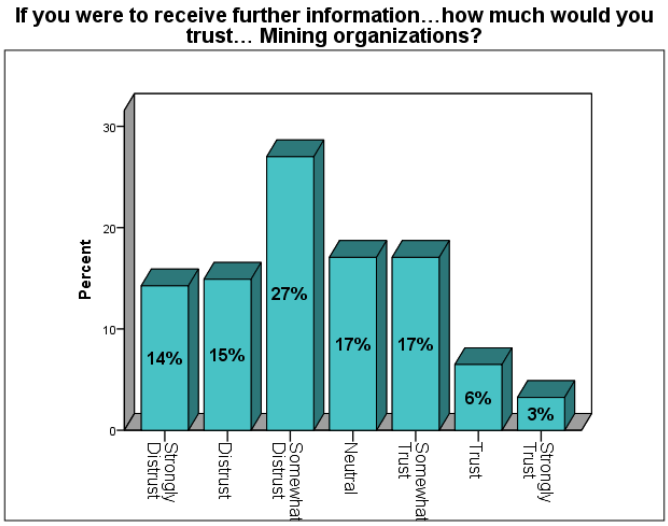

Figure 14. Respondents' level of trust for receiving further information on MMM from mining organizations. N=463.

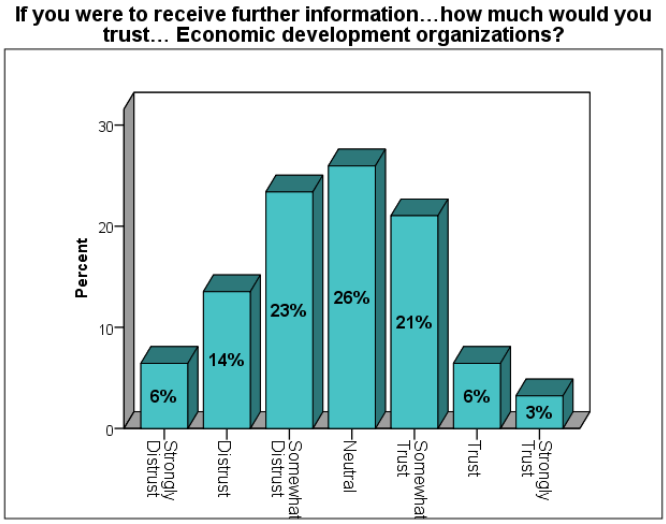

Figure 15. Respondents' level of trust for receiving further information on MMM from economic development organizations. N=466.

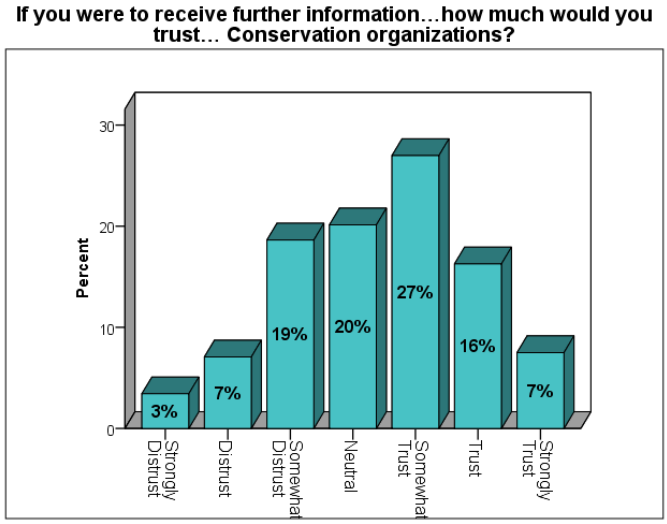

Figure 16. Respondents' level of trust for receiving further information on MMM from conservation organizations. N=467.

Economic development organizations were trusted slightly more than mining organizations (Fig. 14) with 27% trusting or somewhat trusting, and only 3% strongly trusting them as future information sources on MMM. Figure 15 shows that 43% somewhat trusted or trusted conservation organizations while just 7% strongly trusted them.

Both the state government and federal government (Fig. 16 & 17) only had a quarter of participants have some level of trust in them as information sources on MMM.

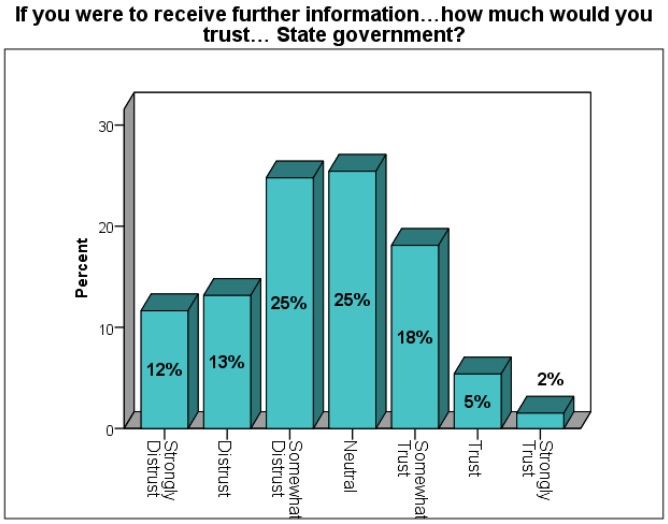

Figure 17. Respondents' level of trust for receiving further information on MMM from the state government. N=464.

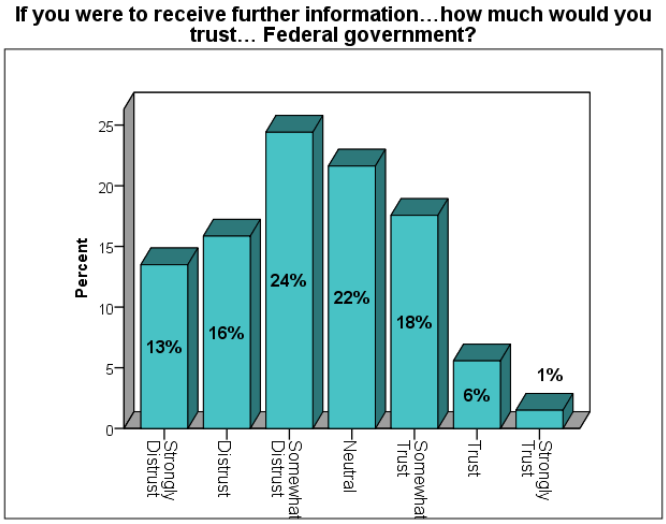

Figure 18. Respondents' level of trust for receiving further information on MMM from the federal government. N=467.

Yet, 86% and 85% believed that water quality regulations and oversight by Maine Department of Environmental Protection would reduce negative environmental impacts of MMM in Maine respectively (Fig. 18 & 19).

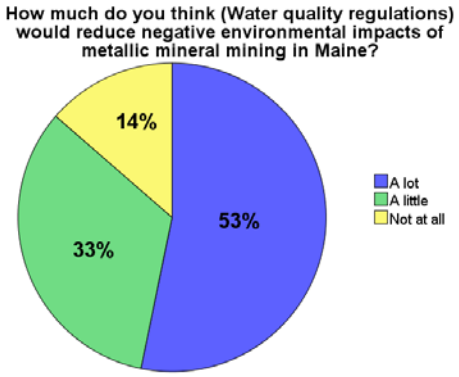

Figure 19. How much respondents' thought water quality regulations would reduce environmental impacts of MMM in Maine. N=462.

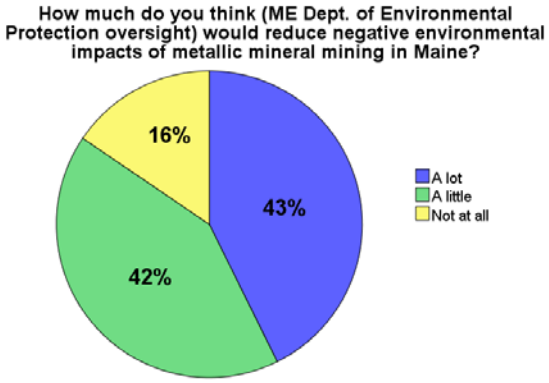

Figure 20. How much respondents' thought DEP oversight would reduce environmental impacts of MMM in Maine. N464.

Conversely, in Figures 20 & 21 over one-third (39% and 36%) believed that environmental monitoring and upfront financial assurances by private mining companies would not reduce negative environmental impacts.

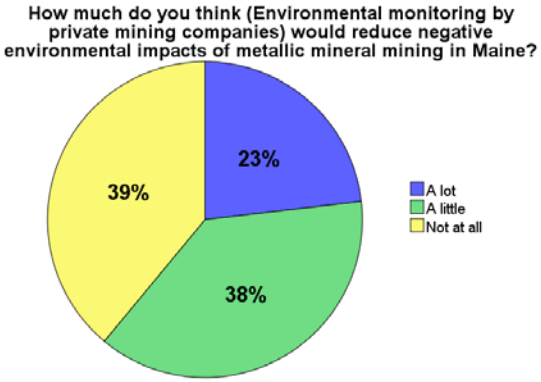

Figure 21. How much respondents' thought environmental monitoring by private mining companies would reduce environmental impacts of MMM in Maine. N=462.

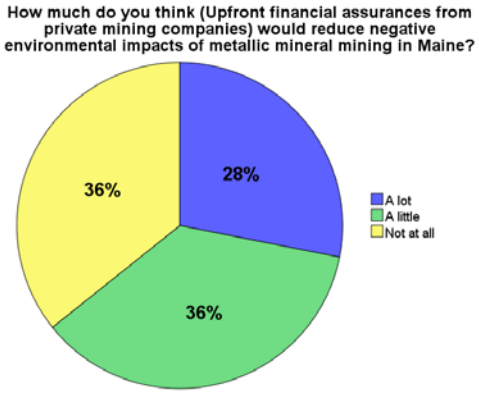

Figure 22. How much respondents' thought upfront financial assurances from private mining companies would reduce environmental impacts of MMM in Maine. N=459.

4.2.4. Risk Assessment

This section displays results of questions that assessed participants' perception of the risks of MMM if mines were developed near their community and in Maine overall. Over half (59%) expressed concern if a metallic mineral mine were developed near their community (Fig. 22) and 64% expressed agreement that such a mine would be harmful to the local natural environment (Fig. 23).

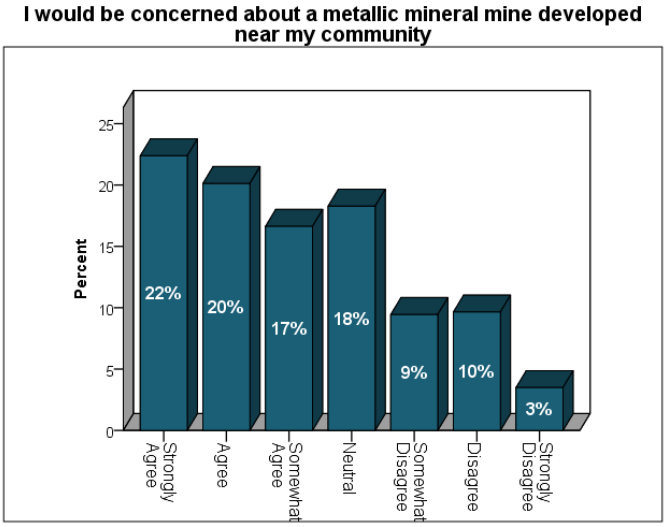

Figure 23. Respondents' level of agreement to the statement "I would be concerned about a metallic mineral mine developed near my community." N=487.

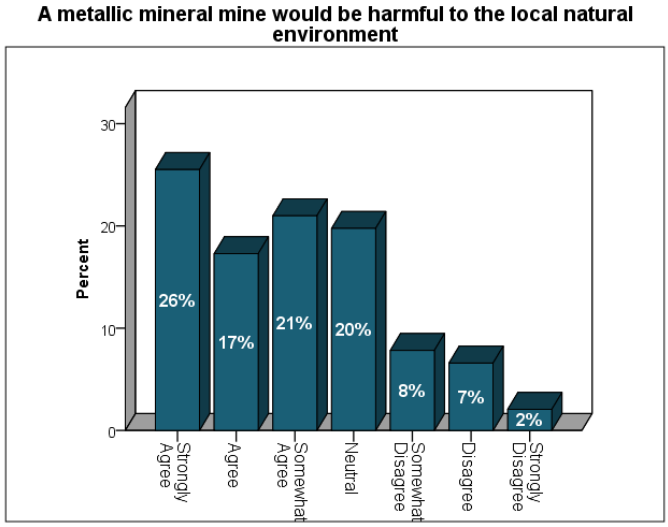

Figure 24. Respondents' level of agreement to the statement "A metallic mineral mine would be harmful to the local natural environment." N=486.

In Figure 24, a third (34%) agreed or somewhat agreed that a metallic mineral mine would be beneficial to their community. Only 6% strongly agreed with this statement.

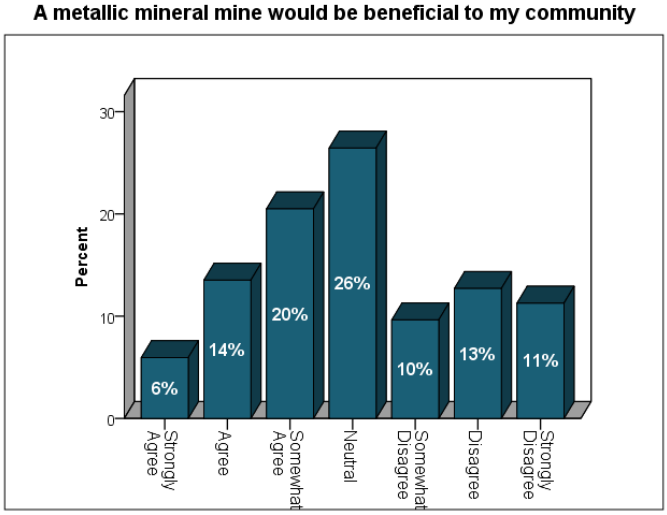

Figure 25. Respondents' level of agreement to the statement "A metallic mineral mine would be beneficial to my community." N=488.

In asking about mine development in Maine overall, 63% had some level of agreement that the negative impacts of MMM outweigh the benefits (Fig. 25). Only 17% expressed any disagreement to this

statement. In Figure 26, 41% had some level of agreement to the statement that “metallic mineral mining would be harmful to Maine’s natural environment” while a third (32%) were neutral towards the statement.

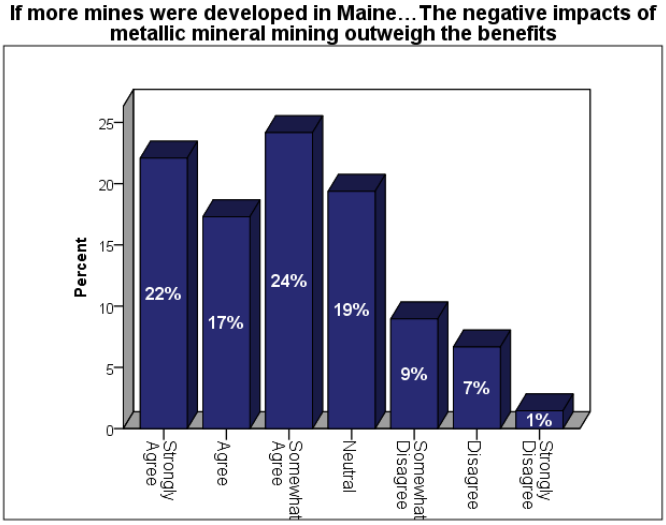

Figure 26. Respondents' level of agreement to the statement "the negative impacts of metallic mineral mining outweigh the benefits." N=480.

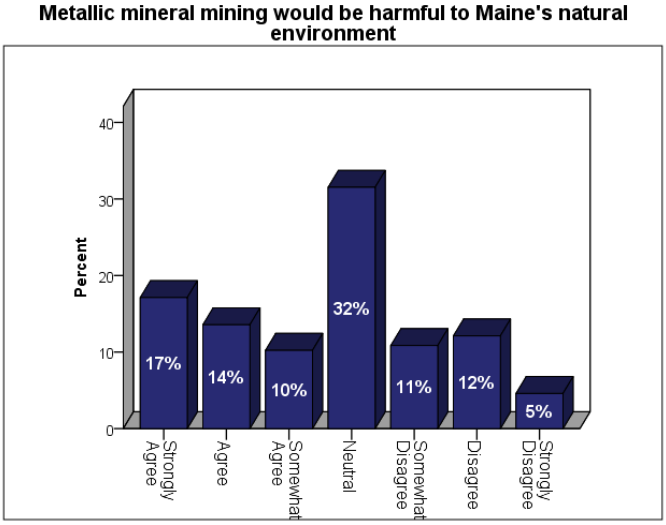

Figure 27. Respondents' level of agreement to the statement "metallic mineral mining would be harmful to Maine's natural environment." N=479.

Participants were also asked if they believed certain things would increase, decrease, or remain constant if a mine was developed near their community. In Figure 27, over half (53%) believed human health would decrease and 43% believed it would remain constant. Over two-thirds (69%) believed that fish and wildlife health would decrease (Fig. 28).

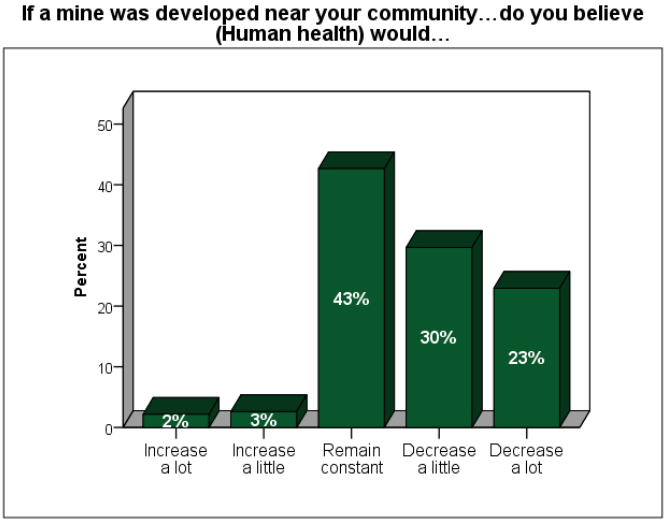

Figure 28. Perceived impact to human health of a potential mine near respondents’ community. N=462.

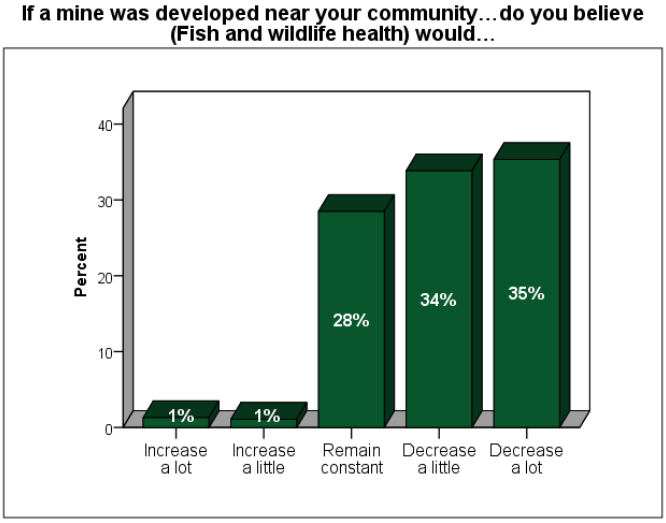

Figure 29. Perceived impact to fish and wildlife health of a potential mine near respondents’ community. N=467.

Similarly, over two-thirds (67%) believed that water quality would decrease (Fig. 29). In Figure 30, over half (54%) believed that nature based tourism would decrease.

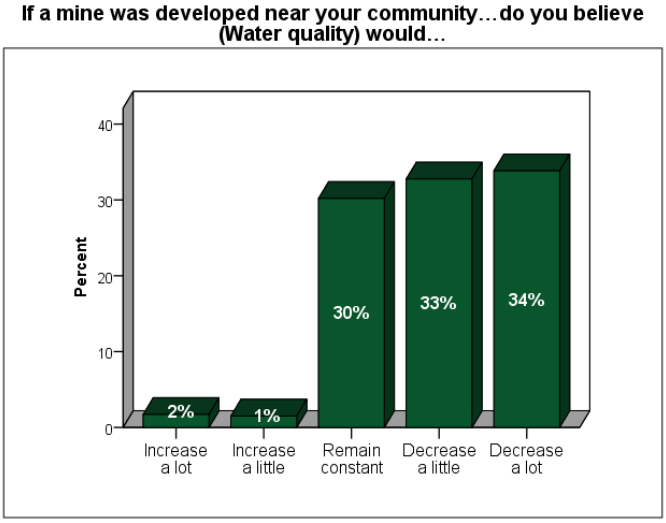

Figure 30. Perceived impact to water quality of a potential mine near respondents' community. N=467.

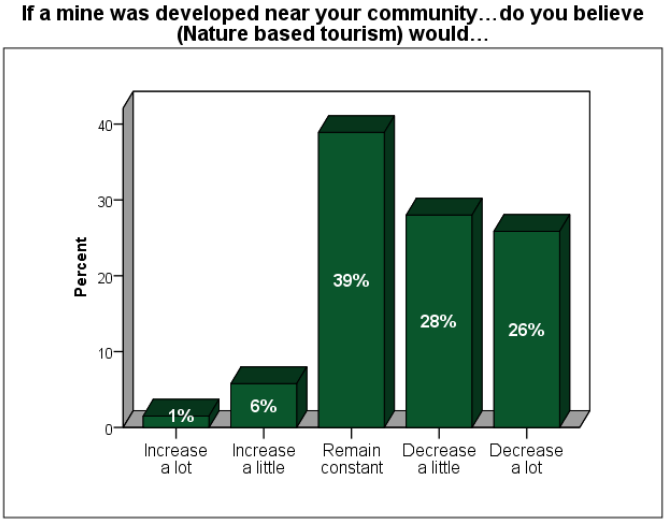

Figure 31. Perceived impact to nature based tourism of a potential mine near respondents' community. N=468.

In Figure 31 78% believed employment opportunities would increase. Yet, 44% believed that house/property values would decrease (Fig. 32).

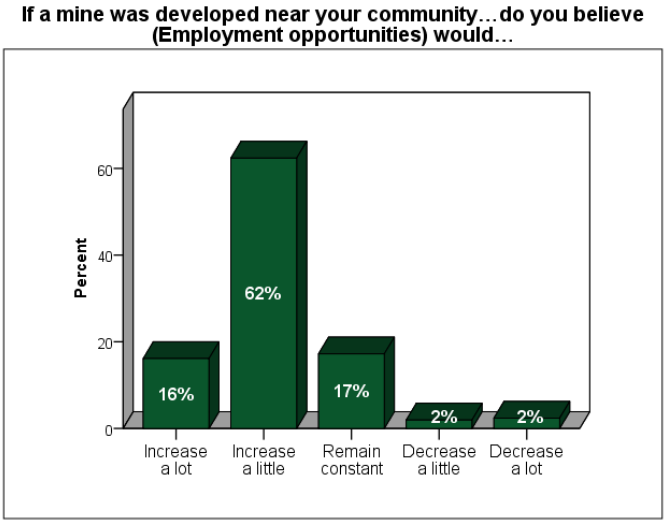

Figure 32. Perceived impact to employment opportunities of a potential mine near respondents' community. N=465.

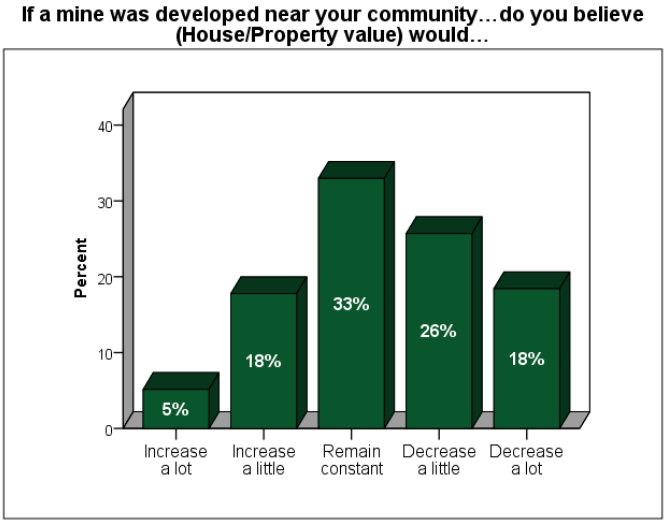

Figure 33. Perceived impact to house/property value of a potential mine near respondents' community. N=467.

5. Principal Findings and Significance

Study Limitations and Considerations for Survey Results:

Though a 19.5% response rate is adequate in social sciences, it is small enough that certain groups in the population may not be adequately represented. In determining the representativeness of the survey, the participants' demographics for gender and political party are nearly identical to that of the Maine population while average age, income, and education are higher, as is often the case with surveys. The distribution of the counties in which participants resided also is different than Maine as a result of the deliberate sampling design to capture more residents within close proximity to deposits.

Key Findings and Recommendations:

- The qualitative results show that, counter intuitively, pushing to get a bill passed can actually hinder the fulfillment of the bill's purpose. Vague language and unclear regulations also have been displayed to pose a barrier for all involved. Those from each side of the discussion desire clear standards. Unclear rules have left the public with misgivings and interested investors with uncertainty about pursuing mining in this state. There are some who are just opposed to mining and are likely to remain so. Yet most just want strong mining rules that protect residents' values and the resources that exist here already.
- Survey participants expressed similar concerns to those expressed in testimony. These concerns include negative impacts to water quality, local environment, human health, and existing industries.
- A large number of survey participants lacked of awareness or information. Approximately 40% incorrectly thought that there were currently active metal mines in the state while nearly two thirds (63.5%) had not heard about the MMM discussion occurring in the state prior to participating in the survey. Of those that did have prior knowledge, three quarters (74%) got their information from newspapers and over two thirds (68%) from local TV/radio news outlets.
  - In order to have more constructive public input on this and other policy topics, increased information may need to be given. Since newspapers and local news outlets were the most prominent sources of information, state government entities should utilize these channels for dispersion of information.
  - Scientists and researchers were the most trusted for future information on MMM (84% had some level of trust). In addition, trust in state government for future information on MMM was low (25% had some level of trust). Therefore, scientists may be able to play as intermediary on controversial issues by providing information to which a wary public may be receptive.
- Survey participants did, however, express that they believed that water quality regulations (86%) and oversight by Maine Department of Environmental Protection (85%) would reduce negative environmental impacts of MMM in Maine.
  - Ensuring water quality regulations and DEP oversight are adequate to reduce negative environmental impacts will play a critical role since nearly 40% of survey participants believed that environmental monitoring by private mining companies would not reduce these impacts.
- It has been expressed both in testimony and by survey participants that negative impacts on the environment from MMM could potentially affect existing industries like tourism. While 55% of

participants agreed that " people in my community are typically supportive of resource extraction jobs", even more (87%) had some form of agreement that 'people in my community are typically supportive of jobs in the tourism industry." Over half (54%) of participants believed nature based tourism would decrease as a result of a potential local mine.

- A fair number of survey respondents (40%) thought that a metallic mineral mine would be beneficial to their community and over three quarters (78%) believed employment opportunities would increase. However, the majority of survey participants agreed that the negative impacts of MMM outweighed the benefits (63%).
- The majority of survey participants (64%) agreed that a metallic mineral mine would be harmful to the local natural environment.
- The majority of survey participants believed that human health (53%), fish and wildlife health (69%), and water quality (67%) would decrease if a metallic mineral mine were developed near their community.

Significance:

This research addressed the social perceptions of metallic mining development in Maine. These included perceptions on the negative and/or positive impacts to local communities and their ability to be economically and environmentally sustainable. Results from this study have been reported to the Maine legislature to help them determine the sustainability of metallic mining in regards to Maine's communities, economies, and natural resources, particularly water resources. We have attempted to gather these perceptions from the widest number of stakeholders, from those who have actively participated in the policy debate to those who had limited knowledge on the topic.

SECTION C.

Student Support:

The project allowed for involvement of one undergraduate student and two graduate students. It also provided the opportunity for undergraduate students (40) and graduate students (9) to participate in a service learning project associated with the project in SFR479 (Environmental Attitudes and Behaviors, taught by Dr. John Daigle). Students enrolled in the course supported instrument development, conducted descriptive data analysis for the pilot online survey results, and gave an oral presentation of preliminary findings.

Presentations:

Environmental Attitudes and Behaviors Course. (2016, May). *Perceptions of metallic mineral mining in Maine.* Class presentation at University of Maine's service learning class presentations, Orono, Maine.

Morgan, A. (2016, September). *Testimony of Andrew Morgan before the Board of Environmental Protection, Neither for nor against the proposed chapter 200: Metallic mineral exploration, advanced exploration and mining.* Testimony presented at the Maine Board of Environmental Protection Public Hearing, Augusta, Maine.

Morgan, A. (2016, December). *Risk perceptions of metallic mineral mining in Maine.* Thesis project proposal presented at the School of Forest Resources, Orono, Maine.

Morgan, A. (2017, January). *Public risk perceptions of metallic mineral mining in Maine: A mixed methods study.* Abstract to present at the International Symposium on Society and Resource Management in Umeå, Sweden on June 19, 2017. Accepted.

Morgan, A. (2017, March). *Public perceptions of metallic mineral mining in Maine.* Poster session presented at the Maine Sustainability and Water Conference, Augusta, Maine.

Proposal Submissions:

De Urioste-Stone, S. (Lead PI), Morgan, A. (Proposal Author). *Travel to present grant proposal.* University of Maine Graduate Student Government. February 9, 2017. Requested, $850; awarded partial funding, $425.

De Urioste-Stone, S. (Lead PI), Morgan, A. (Proposal Author). *2017 Lee & Sunny Allen international experience travel scholarship.* The School of Forest Resources, University of Maine. April 13, 2017. Requested, $700; awarded full funding.

Olsen, A. MacRae, J. & De Urioste-Stone, S.M. 2017. "Attitudes and impacts of mining in Maine: A comparative study". Requested $36,314; proposal submitted to Water Resources Research Institute. (Unfunded).

Publications:

Shepherd, M. 2017. *Why legislating mining in Maine is so hard, in one survey*. News article from the Bangor Daily News. URL: http://stateandcapitol.bangordailynews.com /2017/04/25/ why-legislating-mining-in-maine-is-so-hard-in-one-survey/

Simms, D. (2017, March). *Mitchell Center mining project data to be submitted for legislative consideration.* Press release from the Senator George J. Mitchell Center for Sustainability Solutions. URL: https://umaine.edu/mitchellcenter/category/news/

Morgan, A., De Urioste-Stone, S. (2017, April). *Public perceptions of metallic mineral mining in Maine: Research summary report of preliminary results.* Report to the Maine Legislature's Joint Standing Committee on Environment and Natural Resources, 29 pages.

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Appendix A. Theoretical Framework

"Psychometrics is the study of the operations and procedures used to measure variability in behavior and to connect those measurements to psychological phenomena" (Furr & Bacharach, 2014). Based largely on this theory of psychological measurement, van der Linden's (2015) framework focuses on linking attitudes to behavioral actions. Likewise, the metallic mineral mining risk perception model (MRPM) (Fig. 33) links attitudes with "behavioral action" which in this study's context is acceptance level of metallic mining.

Risk Perceptions

Risk is uncertainty about an event or activity coupled with the possible severity of outcomes (Riesch, 2013). In addition, there are differences between an individual's personal and societal risk perceptions. Van der Linden (2015) found that knowledge was a significant predictor only for societal risk whereas personal experience and egoistic value orientations were only significant predictors of personal risk. Other concepts (e.g., gender, social norms) predicted both types of risk. Societal risk in this context is associated with the state of Maine overall.

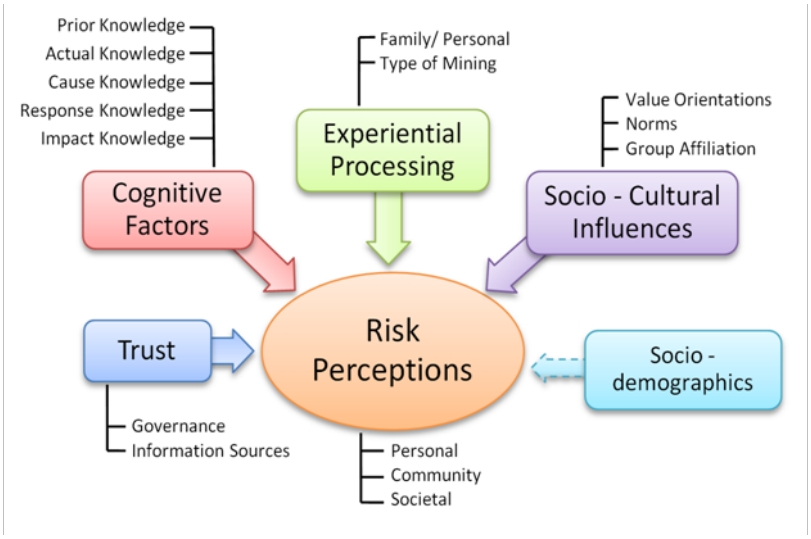


Figure 34. Metallic mineral mining risk perception model. (Adapted from van der Linden, 2015).

Community risk is an added component to the model. This type of risk is important to distinguish from personal and societal because mining costs tend to be disproportionately borne by the local communities whereas the benefits are dispersed throughout society (Campbell & Roberts, 2010). Community risk is also unique because of the "not in my backyard" (NIMBY) phenomena. NIMBY is the "opposition to the siting of locally undesirable land uses…which present unusually high risks" to the local community or natural environment (Kelly, 2011). NIMBYists are not necessarily opposed to land uses like mining they just don't want them near their home (Kelly, 2011). Thus by including community risk along with personal and societal risk variability can be measured. For example, if community risk is high while personal and societal risk is low then the NIMBY phenomena may be present.

Cognitive Factors

In order for the role of knowledge in risk perceptions to be detected, different forms of knowledge should be utilized (Kaiser & Fuhrer, 2003; van der Linden, 2015). This study will measure five interrelated cognitive factors: prior, actual, cause, response, and impact knowledge about metallic mining in Maine. These differ slightly from the original model which distinguished between three types of knowledge: cause, impacts, and response.

The following is an example of how knowledge can influence risk perceptions. When people lack prior knowledge their attitudes can shift with any new information received (Slovic et al., 1982). Heberlein (2012) calls these weak attitudes opinions because they lack cognitive structure. Given the novelty of the MMM topic in Maine, measures of prior knowledge have been added to ascertain if respondents have heard of the topic prior to taking the survey and if so, what sources did this information come from. If a respondent has not heard of the topic before then the survey is their first encounter with MMM. This should be able to explain any inconsistencies with their responses throughout the survey.

Experiential Processing

"Attitudes based on direct experience are better developed. They have more beliefs, they're more stable, and they have stronger affect" (Heberlein, 2012, p26). Personal experience is also connected with heuristics which are mental shortcuts. People often process information about complex risk issues by linking them with past experiences or vivid examples from specific events (Mase et al., 2015). Therefore, if someone has prior experience with mining activities they will associate and evaluate the current MMM issue through those experiences and tend to have stronger attitudes associated with the topic.

Socio-Cultural Influences

Van der Linden's model utilizes broad value orientations to explain risk perceptions. Vaske (2008) distinguishes between value orientations and values which "transcend situations, issues and objects" (e.g., honesty) (p.24). Value orientations, though guided by values, are "patterns of direction and intensity among basic beliefs" which "reflect our thoughts about specific objects or issues" (Vaske, 2008, p. 25). According to van der Linden (2015) three broad value orientations are relevant for environmental issues. These are egoistic, socio-altruistic, and biospheric value orientations (van der Linden, 2015).

Risk perceptions are influenced by interaction with other people and social structures (Joffe, 2003; Kasperson et al., 1988). Norms are one of the most useful and powerful concepts in social psychology (Heberlein, 2012). A key distinction between norms and attitudes is that norms come with sanctions or punishments (Vaske, 2008; Heberlein, 2012). Descriptive norms are behavioral regularities (Heberlein, 2012); they are "what most people are doing" (Vaske, 2008, p. 27). Injunctive norms are "what people should or ought to do in a given situation" (Vaske, 2008, p. 27). These two norms are categorized as social norms where the punishments are administered by others. Personal norms represent an individual's belief system, carry an individual sense of obligation, and have internal sanctions (Heberlein, 2012).

Trust

Though not originally a component of his model van der Linden (2015) suggests that trust factors would be useful additions. This study thus incorporates a trust in information sources component similar to what Mase, et al. (2015) added to the Social Amplification of Risk Framework. When a person feels that an information source shares similar values, is consistent with initial beliefs, and has the public's best interest in mind that source is trusted more; while conversely, information from sources that they feel do not meet those standards are rejected (Mase et al., 2015; Slovic et al., 1982).

Trust is connected to confidence in governance structures which manage risks associated with activities like mining (Mase et al., 2015, Zhang & Moffat, 2015). "Loss of trust can increase risk perceptions, make a risk more unacceptable, and intensify the public response" (Mase et al., 2015, p. 168). Zhang and Moffat (2015) found that environmental concerns were offset and level of acceptance increased if residents perceived that there were strong regulations and the government had the ability to hold the mining industry accountable. Conversely, when governance was perceived to be weak, acceptance level significantly decreased even for those residents with low environmental concerns (Zhang & Moffat, 2015). Therefore a component to measure respondents' perceptions on the ability of different governance structures to reduce negative environmental impacts is also added to the model.

Socio-demographics

Gender and political affiliation were the only socio-demographic factors that influenced risk perceptions with van der Linden's model. Other factors such as income, education, and age had no significant effect on risk perceptions (van der Linden, 2015). This lower explanatory property is reflected in Figure 33 with a dotted outline on the socio-demographics arrow. These socio-demographics are still important because they act as control factors and allow evaluation of how well the sample reflects the population.

Appendix B. IRB Approval Application

3. Participant Recruitment:

Due to the low response rate from the online survey, a mail survey will be used. The same strata will be used to send the survey to Maine residents only. This population will include 3500 individuals, randomly selected; participants will be sent invitations to take the survey via mail and can voluntarily choose to take the survey by responding to a mail-questionnaire. The ages of individuals in this population will include individuals only 18 years and older.

4. Informed Consent:

All potential survey respondents will be provided with consent information before choosing to participate in the survey. At the beginning of the actual survey, participants will be given written details that will describe what they would be asked to do in the survey, the risks they would be undertaking by participating, the benefits they might receive by participating, the procedures for maintaining their confidentiality, and the contact information of the PI of the research team. Participation in surveys will then imply consent to participate. Informed consent is included as part of the questionnaire.

5. Confidentiality:

The following precautions will be addressed to ensure privacy of participants and confidentiality of data collected in this study:

- Responses to the mail survey instrument will not have study participants mails attached to their responses. Only response data will be collected.
- Reports, presentations, and manuscripts will NOT include names of survey respondents, or other identifiable data, in order to preserve privacy of participants.
- Mail addresses will not be linked to data so responses will be anonymous and all data will be kept in a password-protected computer.
- Survey responses will be destroyed after seven years.

6. Risks to Participants:

In the judgment of the Principal Investigator, there are no possible physical, psychological, social, legal, economic, or other risks to the subjects, either immediate or long range. The risk to human subjects is no greater than that of everyday living.

7. Benefits:

Individuals participating in the survey will not gain any direct benefit from participating in the study. Individuals may feel satisfied that their contribution to this survey may be helping express Maine residents' attitudes and level of acceptance of possible metallic mineral mining in the state.

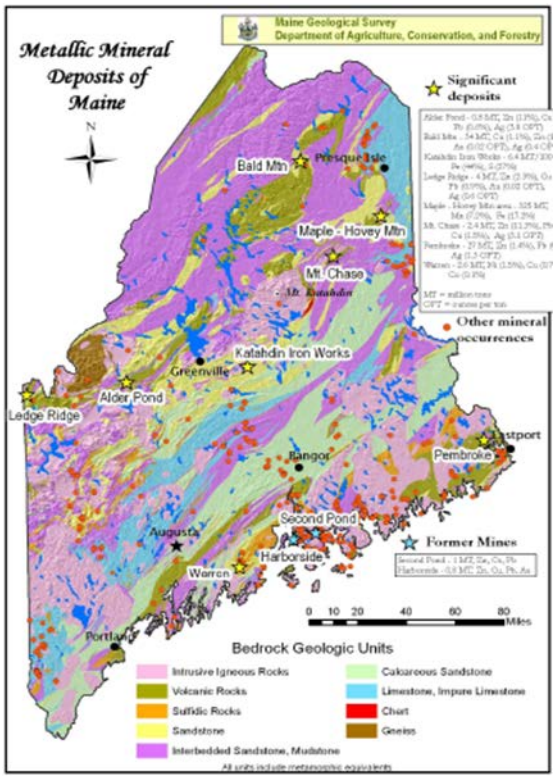
This survey study will greatly assist a funded Water Resources Research Institute (WRRI) research grant and interdisciplinary team of University of Maine faculty that will utilize a mixed methods approach. This approach will gain measures of the social, economic, and ecological benefits and costs potentially derived from future metallic mineral mining in Maine. (LOOK AT Current proposal)

8. Compensation:

At the end of the survey period winners will be chosen to win one of three $50 Hannaford gift cards. Winners will be chosen by randomly selecting three mailing addresses from all participants that returned a survey. The gift cards will be mailed to these three addresses.

Appendix C. Mail Questionnaire

Public Perceptions of Metallic Mineral Mining in Maine



Funding provided by:

Dear Maine Resident,

You are invited to participate in a research project being conducted by Dr. Sandra De Urioste-Stone, a faculty member in the School of Forest Resources at the University of Maine. Maine is currently exploring changes to metallic mineral mining legislation. The purpose of this research is to better understand your views toward metallic mineral mining and the associated benefits and risks. You must be at least 18 years of age to participate.

What you will be asked to do
If you decide to participate, you will be asked to fill out the following questionnaire, which will take approximately 15-20 minutes. You must be at least 18 years of age to participate.

Risks
Except for your time, there are no risks to participate in this study.

Benefits
While this study may have no direct benefit to you, this research will help us better understand resident views toward metallic mineral mining in Maine.

Compensation
By completing and returning this survey, you will be entered into a raffle to win one of three $50 Hannaford gift cards. Winners will be randomly chosen at the end of the survey period and the gift cards will be sent to the same mailing address used to send the survey.

Confidentiality
The survey responses will be confidential. Please do not write your name anywhere on the survey. The survey has an identification number for mailing and raffle purposes– your responses will be held in the strictest confidence; the key will be stored in a locked office for two years. The survey responses will only be published in summarized form, so your individual responses will never be revealed. All data will be kept in a password protected computer. Hard copy surveys will be destroyed after seven years.

Voluntary
Participation is voluntary. You may stop at any time or skip questions that you do not wish to answer. Returning the survey implies consent to participate.

Contact Information

If you have any questions about this study, please contact:

Dr. Sandra De Urioste-Stone
Assistant Professor
University of Maine
(207) 581-2885
sandra.de@maine.edu

If you have any questions about your rights as a research participant, please contact:

Gayle Jones, Assistant
Protection of Human Subjects Review Board
University of Maine
(207) 581-1498
gayle.jones@umit.maine.edu

Thank you for taking the time to complete this survey!

PART A. ***Mining involves the extraction and processing of raw materials from the earth. Given a long history of mining in Maine and across the country, we would like to know about any firsthand experience you may have with mining activities.***

1. **Do you have any family history or personal experience with any type of mining?**
   (e.g., coal, gems, granite, gravel, metals, peat, etc.)

   ☐ Yes *(Please answer 1a & 1b)* ☐ No *(Skip to Part B, in page 4)*

1a. Your family history or personal experience with mining includes...

(Please check all that apply)	In Maine	In another U.S. State	In a foreign country
Having been employed at a mine	☐	☐	☐
Having a family member employed at a mine	☐	☐	☐
Living near an active mine	☐	☐	☐
Visiting near an active mine	☐	☐	☐
Participating in a mining advocacy program	☐	☐	☐
Participating in a group opposing mining	☐	☐	☐
Other (*Please specify*)	☐	☐	☐

1b. What type of mining was associated with your family history or personal experience?

(Please check all that apply)	In Maine	In another U.S. State	In a foreign country
Agricultural minerals *(e.g., peat, potash, etc.)*	☐	☐	☐
Coal	☐	☐	☐
Construction minerals *(e.g., gypsum, mica, etc.)*	☐	☐	☐
Industrial minerals *(e.g., salt, lime, boron, etc.)*	☐	☐	☐
Precious gemstones *(e.g., diamonds, etc.)*	☐	☐	☐
Semi-precious gemstones *(e.g., tourmaline, garnets, etc.)*	☐	☐	☐
Precious metals *(e.g., gold, silver, etc.)*	☐	☐	☐
Non-precious metals *(e.g., iron, copper, zinc, etc.)*	☐	☐	☐
Oil extraction	☐	☐	☐
Sand/Gravel	☐	☐	☐
Stone *(e.g., granite, dimension, etc.)*	☐	☐	☐
Other (*Please specify*)	☐	☐	☐

PART B. ***This part of the survey focuses exclusively on metallic mineral mining in Maine.***

- Metallic mineral mining involves the extraction of metal ore (e.g., copper, gold, iron, zinc, etc.) from the earth and the processing needed to concentrate those metals into usable commodities.
- Modern metallic mineral mines can create job opportunities by employing people to operate large facilities, equipment, and also building new infrastructure.
- As a by-product of the metal extraction process, large amounts of often toxic waste material is generated, which requires careful planning and treatment to prevent polluting the surrounding area. Any non-toxic waste material may be reused for other purposes such as building roads.
- Over the past few years the state government has sought to revise the laws and regulations that govern metallic mineral mining in Maine. Your responses are greatly appreciated and will help us understand Maine residents' opinions concerning this important subject.

2. Are there currently active metallic mineral mines in the state of Maine?

☐ Yes ☐ No

3. Please indicate, to the best of your knowledge, how much you believe that each of the following items contributes to the demand for products derived from metallic mineral mining…

Items	*Please circle one response for each item below.*			
Cell phones, computers, etc.	Major contributor	Minor contributor	No contribution at all	Decreases demand
Construction	Major contributor	Minor contributor	No contribution at all	Decreases demand
Economic growth	Major contributor	Minor contributor	No contribution at all	Decreases demand
Improved recycling for electronics	Major contributor	Minor contributor	No contribution at all	Decreases demand
Jewelry	Major contributor	Minor contributor	No contribution at all	Decreases demand
Owning a car	Major contributor	Minor contributor	No contribution at all	Decreases demand
Recycling	Major contributor	Minor contributor	No contribution at all	Decreases demand

4. **Prior to this survey, were you aware of the current discussion concerning metallic mineral mining in Maine?**

☐ Yes (*Please answer question 4a*) ☐ No *(Skip to question 5)*

4a. If yes, where did you gain your information? *(Please check all that apply)*

☐ Newspaper *(paper or online)*
☐ Local TV/Radio news
☐ Family member
☐ Friend
☐ Scientists/researchers
☐ Maine state government
☐ Mining organizations *(e.g., Aroostook Resources)*
☐ Economic development organizations *(e.g., Chambers of Commerce)*
☐ Conservation organizations *(e.g., Natural Resource Council of Maine)*
☐ Other *(Please specify)* _____

5. **If you were to receive further information about metallic mineral mining in Maine, how much would you trust or distrust the following agencies, organizations, and groups?**

Information Source	*Please circle one response for each source of information below.*						
Newspaper *(paper or online)*	Strongly Distrust	Distrust	Somewhat Distrust	Neutral	Somewhat Trust	Trust	Strongly Trust
Local TV/Radio news	Strongly Distrust	Distrust	Somewhat Distrust	Neutral	Somewhat Trust	Trust	Strongly Trust
Family members	Strongly Distrust	Distrust	Somewhat Distrust	Neutral	Somewhat Trust	Trust	Strongly Trust
Friends	Strongly Distrust	Distrust	Somewhat Distrust	Neutral	Somewhat Trust	Trust	Strongly Trust
Scientists/researchers	Strongly Distrust	Distrust	Somewhat Distrust	Neutral	Somewhat Trust	Trust	Strongly Trust
Mining organizations	Strongly Distrust	Distrust	Somewhat Distrust	Neutral	Somewhat Trust	Trust	Strongly Trust
Economic development organizations	Strongly Distrust	Distrust	Somewhat Distrust	Neutral	Somewhat Trust	Trust	Strongly Trust
Conservation organizations	Strongly Distrust	Distrust	Somewhat Distrust	Neutral	Somewhat Trust	Trust	Strongly Trust
Local government	Strongly Distrust	Distrust	Somewhat Distrust	Neutral	Somewhat Trust	Trust	Strongly Trust
State government	Strongly Distrust	Distrust	Somewhat Distrust	Neutral	Somewhat Trust	Trust	Strongly Trust
Federal government	Strongly Distrust	Distrust	Somewhat Distrust	Neutral	Somewhat Trust	Trust	Strongly Trust
Other *(Please specify)*	Strongly Distrust	Distrust	Somewhat Distrust	Neutral	Somewhat Trust	Trust	Strongly Trust

6. **Please indicate your level of agreement or disagreement with the following statements about <u>your community and the people close to you…</u>**

Statement	*Please circle one response for each statement below.*						
Good job opportunities are available to people who live in my community	Strongly Agree	Agree	Somewhat Agree	Neutral	Somewhat Disagree	Disagree	Strongly Disagree
I am concerned about people leaving my town to live elsewhere	Strongly Agree	Agree	Somewhat Agree	Neutral	Somewhat Disagree	Disagree	Strongly Disagree
People in my community are typically supportive of resource extraction jobs *(e.g., forest products, fishing, mining)*	Strongly Agree	Agree	Somewhat Agree	Neutral	Somewhat Disagree	Disagree	Strongly Disagree
I am concerned about my community's ability to attract young people	Strongly Agree	Agree	Somewhat Agree	Neutral	Somewhat Disagree	Disagree	Strongly Disagree
Limited job opportunities have caused the departure of people who lived in my community	Strongly Agree	Agree	Somewhat Agree	Neutral	Somewhat Disagree	Disagree	Strongly Disagree
People in my community are typically supportive of jobs in the tourism industry *(e.g., guides, hotels, restaurants)*	Strongly Agree	Agree	Somewhat Agree	Neutral	Somewhat Disagree	Disagree	Strongly Disagree
People who are important to me would think highly of me for getting a job at a metallic mineral mine in Maine	Strongly Agree	Agree	Somewhat Agree	Neutral	Somewhat Disagree	Disagree	Strongly Disagree
People whose opinion I value think that metallic mineral mining may have positive impacts in Maine	Strongly Agree	Agree	Somewhat Agree	Neutral	Somewhat Disagree	Disagree	Strongly Disagree
People whose opinion I value think that metallic mineral mining may have negative impacts in Maine	Strongly Agree	Agree	Somewhat Agree	Neutral	Somewhat Disagree	Disagree	Strongly Disagree
Metallic mineral mining would fit with my perception of the Maine identity	Strongly Agree	Agree	Somewhat Agree	Neutral	Somewhat Disagree	Disagree	Strongly Disagree

7. **<u>If</u> a metallic mineral mine was developed <u>near your community</u>, please indicate your level of agreement or disagreement with the following statements about <u>yourself and your community</u>…**

Statement	*Please circle one response for each statement below.*						
A metallic mineral mine would improve my current employment situation	Strongly Agree	Agree	Somewhat Agree	Neutral	Somewhat Disagree	Disagree	Strongly Disagree
A metallic mineral mine would be harmful to me	Strongly Agree	Agree	Somewhat Agree	Neutral	Somewhat Disagree	Disagree	Strongly Disagree
I would be concerned about a metallic mineral mine developed near my community	Strongly Agree	Agree	Somewhat Agree	Neutral	Somewhat Disagree	Disagree	Strongly Disagree
A metallic mineral mine would be beneficial to my community	Strongly Agree	Agree	Somewhat Agree	Neutral	Somewhat Disagree	Disagree	Strongly Disagree
I would support the development of a metallic mineral mine near my community	Strongly Agree	Agree	Somewhat Agree	Neutral	Somewhat Disagree	Disagree	Strongly Disagree
A metallic mineral mine would only have short-term economic benefits for my community	Strongly Agree	Agree	Somewhat Agree	Neutral	Somewhat Disagree	Disagree	Strongly Disagree
A metallic mineral mine would have long-term economic benefits for my community	Strongly Agree	Agree	Somewhat Agree	Neutral	Somewhat Disagree	Disagree	Strongly Disagree
A metallic mineral mine would be harmful to the local natural environment	Strongly Agree	Agree	Somewhat Agree	Neutral	Somewhat Disagree	Disagree	Strongly Disagree

8. **<u>If</u> more metallic mineral mines were developed <u>in Maine</u>, please indicate your level of agreement or disagreement with the following statements...**

Statement	*Please circle one response for each statement below.*						
The benefits of metallic mineral mining outweigh the negative impacts	Strongly Agree	Agree	Somewhat Agree	Neutral	Somewhat Disagree	Disagree	Strongly Disagree
Metallic mineral mining would be harmful to Maine's natural environment	Strongly Agree	Agree	Somewhat Agree	Neutral	Somewhat Disagree	Disagree	Strongly Disagree
Metallic mineral mining should occur in Maine	Strongly Agree	Agree	Somewhat Agree	Neutral	Somewhat Disagree	Disagree	Strongly Disagree
Metallic mineral mining would only have short-term economic benefits in Maine	Strongly Agree	Agree	Somewhat Agree	Neutral	Somewhat Disagree	Disagree	Strongly Disagree
Metallic mineral mining would have long-term economic benefits in Maine	Strongly Agree	Agree	Somewhat Agree	Neutral	Somewhat Disagree	Disagree	Strongly Disagree
The negative impacts of metallic mineral mining outweigh the benefits	Strongly Agree	Agree	Somewhat Agree	Neutral	Somewhat Disagree	Disagree	Strongly Disagree

9. **How much do you think that each of the following strategies, <u>if implemented</u>, would reduce negative environmental impacts of metallic mineral mining in Maine?**

_____ is likely to reduce negative environmental impacts…	*Please circle one response for each strategy below.*		
Water quality regulations	A lot	A little	Not at all
Pre-site planning	A lot	A little	Not at all
ME Dept. of Environmental Protection oversight	A lot	A little	Not at all
Closure and site reclamation plan	A lot	A little	Not at all
New technologies for metallic mineral mining	A lot	A little	Not at all
Environmental monitoring by private mining companies	A lot	A little	Not at all
Upfront financial assurances from private mining companies	A lot	A little	Not at all
Other *(Please specify)*	A lot	A little	Not at all

10. <u>If</u> a metallic mineral mine was developed <u>near your community</u>, please indicate whether you believe that the following items would be likely to increase, remain constant, or decrease...

_____ is likely to…	*Please circle one response for each item below.*				
Nature based tourism	Increase a lot	Increase a little	Remain Constant	Decrease a little	Decrease a lot
Outdoor recreation	Increase a lot	Increase a little	Remain Constant	Decrease a little	Decrease a lot
Human health	Increase a lot	Increase a little	Remain Constant	Decrease a little	Decrease a lot
Fish and wildlife health	Increase a lot	Increase a little	Remain Constant	Decrease a little	Decrease a lot
Water quality	Increase a lot	Increase a little	Remain Constant	Decrease a little	Decrease a lot
Land pollution	Increase a lot	Increase a little	Remain Constant	Decrease a little	Decrease a lot
Noise pollution	Increase a lot	Increase a little	Remain Constant	Decrease a little	Decrease a lot
Human population	Increase a lot	Increase a little	Remain Constant	Decrease a little	Decrease a lot
Employment opportunities	Increase a lot	Increase a little	Remain Constant	Decrease a little	Decrease a lot
Rural development	Increase a lot	Increase a little	Remain Constant	Decrease a little	Decrease a lot
House/Property value	Increase a lot	Increase a little	Remain Constant	Decrease a little	Decrease a lot
Infrastructure improvement	Increase a lot	Increase a little	Remain Constant	Decrease a little	Decrease a lot
Traffic	Increase a lot	Increase a little	Remain Constant	Decrease a little	Decrease a lot
Local tax revenue	Increase a lot	Increase a little	Remain Constant	Decrease a little	Decrease a lot
State tax revenue	Increase a lot	Increase a little	Remain Constant	Decrease a little	Decrease a lot
Influence of state government	Increase a lot	Increase a little	Remain Constant	Decrease a little	Decrease a lot
Other *(Please specify)*	Increase a lot	Increase a little	Remain Constant	Decrease a little	Decrease a lot

PART C. ***This part asks you about your general values to life. This will give us a framework for studying Maine residents' attitudes and opinions related to metallic mineral mining.***

11. For each value listed below, please rate the extent to which you consider it to be a 'GUIDING PRINCIPLE IN YOUR LIFE':

Value	*(Please circle one response for each statement)*								
Wealth *(possessions, financial success)*	Opposed to my values	Not important	Of little importance	Somewhat important	Important	Slightly more than important	Quite important	Very important	Of Supreme importance
Preventing Pollution **(***protecting natural resources)*	Opposed to my values	Not important	Of little importance	Somewhat important	Important	Slightly more than important	Quite important	Very important	Of Supreme importance
Peace *(a world free of war and conflict)*	Opposed to my values	Not important	Of little importance	Somewhat important	Important	Slightly more than important	Quite important	Very important	Of Supreme importance
Protecting the Environment *(preserving nature)*	Opposed to my values	Not important	Of little importance	Somewhat important	Important	Slightly more than important	Quite important	Very important	Of Supreme importance
Social Power **(***control over others, dominance)*	Opposed to my values	Not important	Of little importance	Somewhat important	Important	Slightly more than important	Quite important	Very important	Of Supreme importance
Helpful *(working for the welfare of others)*	Opposed to my values	Not important	Of little importance	Somewhat important	Important	Slightly more than important	Quite important	Very important	Of Supreme importance
Authority *(the right to lead or command)*	Opposed to my values	Not important	Of little importance	Somewhat important	Important	Slightly more than important	Quite important	Very important	Of Supreme importance
Social Justice *(correcting injustice, care for the weak)*	Opposed to my values	Not important	Of little importance	Somewhat important	Important	Slightly more than important	Quite important	Very important	Of Supreme importance
Respecting the Earth *(harmony with other species)*	Opposed to my values	Not important	Of little importance	Somewhat important	Important	Slightly more than important	Quite important	Very important	Of Supreme importance
Influential *(having an impact on people and events)*	Opposed to my values	Not important	Of little importance	Somewhat important	Important	Slightly more than important	Quite important	Very important	Of Supreme importance
Unity with Nature *(fitting into nature)*	Opposed to my values	Not important	Of little importance	Somewhat important	Important	Slightly more than important	Quite important	Very important	Of Supreme importance
Equality *(equal opportunity for all)*	Opposed to my values	Not important	Of little importance	Somewhat important	Important	Slightly more than important	Quite important	Very important	Of Supreme importance

PART D. ***This final section of the survey asks some background information about you. Your answers, as with all of the answers you provide, will remain confidential.***

12. Which Maine County do you currently reside in?

☐ Androscoggin	☐ Hancock	☐ Oxford	☐ Somerset
☐ Aroostook	☐ Kennebec	☐ Penobscot	☐ Waldo
☐ Cumberland	☐ Knox	☐ Piscataquis	☐ Washington
☐ Franklin	☐ Lincoln	☐ Sagadahoc	☐ York

13. How many years have you lived in the state of Maine?_____ years

14. What is your gender? ☐ Male ☐ Female

15. What is your ethnic background? *(you may select more than one)*

☐ African-American	☐ Native American
☐ Asian-Pacific Islander	☐ White
☐ Hispanic	☐ Other *(Please specify)*_____

16. What is your age? _____ years

17. What is the highest level of education you have completed?

☐ Less than High school	☐ 4-year college degree (BA, BS)
☐ High school or GED	☐ Master's degree
☐ Some college	☐ Doctoral degree (PhD)
☐ 2-yr college degree (AA, AS)	☐ Professional degree (MD, JD, etc.)

18. What is your current employment status? *(Please check all that apply)*

☐ Part-time	☐ Retired
☐ Full-time	☐ Unemployed, seeking employment
☐ Self-employed	☐ Unemployed, not seeking employment
☐ Student	☐ Unable to work

19. What is your current annual household income in US dollars before taxes?

☐ Less than $10,000	☐ $35,000 - $49,999
☐ $10,000 - $14,999	☐ $50,000 - $74,999
☐ $15,000 - $24,999	☐ $75,000 - $99,999
☐ $25,000 - $34,999	☐ $100,000 or more

20. What is your political affiliation?

☐ Democrat	☐ Independent
☐ Republican	☐ Other *(Please specify)* _____

21. Do you belong to any organizations related to conservation, tourism, recreation, or economic development?

☐ Yes (*Please answer question 21a*) ☐ No (*Please skip to question 22*)

21a. If yes, for each category please list the organizations to which you belong.

- ☐ Conservation _____
- ☐ Tourism or Recreation _____
- ☐ Economic Development _____

22. Please feel free to add any additional comments regarding the topic of metallic mineral mining in Maine.

_____

_____

_____

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Thank you for participating in our survey!
Your responses are greatly appreciated

Information Transfer Program Introduction

Information Transfer activities for the Maine Water Resources Research Institute (Maine WRRI) are an important part of our mission. Information Transfer activities can be categorized as: 1) Conferences and lectures; 2) Digital media; 3) K-12 education; 4) Stakeholder engagement; and 5) Other project outputs.

In additional to the effort made directly by the Maine WRRI, we require funded researchers to include information transfer activities in their projects. This includes presentation of research results at the Maine Sustainability & Water Conference, creation of a project summary written for a general audience for web and print with assistance from our science writer, progress reports, and manuscripts for publication. All projects require that researchers engage with stakeholders with the goal of generating solutions-driven research.

Maine Information Transfer

Basic Information

Title:	Maine Information Transfer
Project Number:	2016ME317B
Start Date:	3/1/2016
End Date:	2/28/2018
Funding Source:	104B
Congressional District:	1
Research Category:	Not Applicable
Focus Category:	Education, None, None
Descriptors:	None
Principal Investigators:	John M. Peckenham, David Hart

Publications

There are no publications.

1. Conferences and Lectures

Maine Sustainability & Water Conference

The Maine Sustainability & Water Conference was launched in 1994 with a primary focus on one of Maine's central challenges–the future of its water resources. Originally designed to provide a collaborative nexus for water resource professionals, researchers, consultants, citizens, students, regulators, and planners to exchange information and present new findings on water resource issues in Maine, the conference has grown to include participation from a broad audience of close to 400 participants from across the state. In response to many requests, the conference's focus has expanded to encompass a wide range of sustainability challenges facing Maine, including issues related to climate change, energy futures, agriculture, forestry, fisheries, tourism, and municipal planning. Many of these topics are also integrally interwoven with Maine's water resource issues and needs.

The conference continues to be the most important information transfer event for the Maine WRRI. In FY16 our plenary speaker was Carol Collier, Senior Advisor for Watershed Management and Policy at Drexel University Academy of Natural Sciences. Carol's talk was titled, *"Bridging the Gap between Science and Policy: Lessons Learned from the Delaware River Watershed*". Carol shared her experiences from her 15+ years at the Delaware River Basin Commission and her current work on the Delaware River Watershed Initiative.

The conference included the following concurrent sessions:

- Climate Change and Extreme Events in Maine and the Northeast – Coastal Issues/Inland Issues
- Water Quality Monitoring: Innovations and Outcomes
- Stream Connectivity Resource Workshop
- Climate, Water + Health
- Safe Beaches & Shellfish
- Dams and Decision-making
- Research and Management of Maine's Drinking Water Sources and Watersheds
- A Rising Tide Floats All Boats – Innovative Strategies for Building Resilience through Collaboration
- Groundsource Heat Exchange – Geothermal Technologies for Heating and Cooling
- Channeling Cross-sector Collaboration for Healthy Maine Lakes
- Talking Trash: The Sustainability Challenge Hiding in Plain Sight
- Building a Sustainable Food System
- Land Conservation, Forestry, and the Future of Maine's Forest-dependent Economy
- Maine's Energy Future
- More Than an Island — Collaborative Water Research and Monitoring in Acadia National Park

A highlight of the conference is the student poster competition featuring undergraduate and graduate judging categories. Twelve undergraduate students and 17 graduate students presented posters at the 2016 conference. The undergraduate poster winner was Cailene

Gunn from Bates College with a poster titled, "Methane fluxes along a salinity gradient on a restored salt marsh, Harpswell, ME". The graduate poster winner was Kelli Straka from the University of Maine's School of Earth and Climate Sciences for her poster, "Quantifying groundwater exchange and variability of hydrologic fluxes in New England vernal pools." Kelli's research was funded by a FY15 WRRI grant.

Full details about the conference, including links to presentations and award winners, can be found online at: umaine.edu/mitchellcenter/news/maine-water-conference/2016-maine-sustainability-water-conference/.

Senator George J. Mitchell Lecture on Sustainability

Launched in 2007, the Senator George J. Mitchell Lecture on Sustainability serves as an extraordinary forum in which the university community, the general public, and many others can learn from and interact with some of the world's leading thinkers about the challenges and opportunities involved in accelerating the transition to a sustainable world. Sharing the stage with these extraordinary thought leaders, Senator Mitchell offers his compelling insights about the importance of sustainable development, a subject he first addressed in his 1991 book, "*World on Fire: Saving an Endangered Earth"*.

Ruth DeFries, Denning Family Professor of Sustainable Development at Columbia University, New York, gave the 2016 Mitchell Lecture. Ruth's talk, "Between Optimism and Pessimism: Our Unending Pursuit to Feed Civilization", was based on her book, The Big Ratchet, which traces the long journey of our species from hunters and gatherers to shoppers in the aisles of grocery stores. Through technologies, innovations, and quirks of fate, people over millennia have manipulated ecological processes to propel our species to the current day of abundant food amidst myriad environmental and social consequences. From this long-term view, the pattern shows neither collapse nor technological supremacy. Rather, our tenure on the planet reveals cycles of crisis and growth, with each innovation leading to a new set of ecological problems that in turn spur new innovations. Ruth discussed the next step in this long cycle toward science-based, non-ideological solutions to the problems that our success has created.

More information on this and prior Mitchell Lectures is available at: https://umaine.edu/mitchellcenter/news/mitchell-lecture/.

Weekly Speaker Series

The Mitchell Center hosts a weekly speaker series during fall and spring semesters. These talks are available via video conferencing and streaming for off-campus researchers, students and stakeholder, and are also recorded and posted to our Video-on-Demand page. In FY16 the following talks were supported in part by the Maine WRRI:

- March 21, 2016 - Anticipating Surprises: The Role of Winter Weather-Climate Variability on Lake Ice Regimes in Maine. Speaker: Mussie Beyene, PhD Candidate, Civil & Environmental Engineering, UMaine

- March 28, 2016 - Bridging the Gap between Science and Policy: Lessons Learned from the Delaware River Watershed. Speaker: Carol Collier, Senior Advisor for Watershed Management and Policy, Drexel University Academy of Natural Sciences
- May 2, 2016 - A World Upside Down: Charting climate and biodiversity futures in Africa and the global south**.** Speaker: Phoebe Barnard, South African National Biodiversity Institute
- September 2, 2016 - Disturbance and Restoration in Streams. Speaker: Sam Lake, Emeritus Professor, Monash University, Melbourne, Australia6
- September 12, 2016 - Does the value of nature depend on whom you ask? Should it? Speaker: Aaron Strong, Assistant Professor, School of Marine Sciences, University of Maine
- September 26, 2016 - Indicators of Community Well-Being for Maine's Coast and Islands: Initial Results and Opportunities for Collaborative Research. Speaker: Heather Deese, Vice President, Research & Strategy, Island Institute
- October 3, 2016 - Conserving Small Natural Features with Large Ecological Importance. Speakers: Aram Calhoun and Malcolm 'Mac' Hunter, Professors, Wildlife, Fisheries & Conservation Biology, UMaine
- October 17, 2016 - Creating a Decision Support Toolbox for Safe Beaches & Shellfish Harvests. Speakers: Kate Beard, Damian Brady, Brian McGill, Bridie McGreavy, Sam Roy, Sean Smith; Decision Support Systems Team, NEST Safe Beaches & Shellfish
- November 7, 2016 - Resilient Communities and Fisheries Arise from Resilient Ecosystems. Speaker: Richard Merrick, Director, Scientific Programs and Chief Science Advisor, NOAA Fisheries
- November 14, 2016 - Scaling Conservation: Translating Local Success into Global Impact**.** Speaker: Kate Dempsey, State Director of The Nature Conservancy in Maine
- December 5, 2016 - Damned If You Do, Dammed If You Don't: The Evolution of Pro-Active Dam Removal over the Last Quarter Century. Speaker: Laura Wildman, Director, New England Regional Office, Princeton Hydro
- January 23, 2017 - From Frog Fungus to Smashed Dams; Maine science journalism and the (messed up) food chain of news. Speaker: Murray Carpenter, author and journalist
- February 20, 2017 - Food and Water Go Well Together – Pairing Stakeholder Engagement with Agriculture and Water Quality Management in the Chesapeake Bay Watershed. Speakers: Kelly Shenk, Agricultural Advisor, U.S. Environmental Protection Agency, Region III; Gary Shenk, Hydrologist, USGS at the Chesapeake Bay Program Office

2. Digital Media

Website

The Mitchell Center's web site is the most important location for finding information on upcoming events, current activities, projects and publications. Information on the Maine WRRI is located on the Mitchell Center site and is updated on a regular basis. Information includes project summaries, outputs such as publications and presentations, and upcoming

funding opportunities such as proposal requests for 104b and 104g programs.

E-newsletter and News Posts
The Mitchell Center publishes an e-newsletter on a regular basis (every 2-3 weeks). Over 2,000 subscribers receive the newsletter, which includes short news articles and information on upcoming activities and events. The news articles in the e-newsletter link directly to full news posts on the Mitchell Center website. All information on Maine WRRI programs, such as requests for proposals, announcements of new projects, and related news articles and student stories, are included in the e-newsletter.

Facebook
The Mitchell Center's Facebook page is available at www.facebook.com/MitchellCenterForSustainabilitySolutions/. The page is used to provide brief updates and links to interesting information from the Mitchell Center and our researchers, students and partners. Our goal is to post 2-3 items per week. Interest in the page has increased significantly over the last 12 months and averages 400 likes per week.

3. K-12 Education

On Tuesday, October 11, 2016, the Maine WRRI helped organize and participate in the Northern Maine Children's Water Festival. Two Mitchell Center staff are directly involved in organizing the event. The festival, which is held every other year, promotes hands on learning about water issues and brings together over 650 fifth and sixth grade students and their teachers. Water resource professionals from Maine and New England provided presentations and activities about water, wetlands, human health and aquatic life; there were water trivia quiz shows hosted by local radio and television personalities, as well as activities using music and art. This experience was provided at no cost to the participants. In fact, the festival provided funding to help schools cover the cost of transportation. The festival goals are to teach students about the value of clean water and healthy habitats, and to provide teachers with materials and lessons that they can use for years to come.

We were very pleased with the level of participation and sponsorship for the 2016 festival, which was much higher than in prior years. Sponsors included private companies, academic institutions, non-governmental organizations, state government agencies and professional associations.

4. Stakeholder Engagement

The Mitchell Center's focus is on innovative stakeholder-engaged, solutions-driven, interdisciplinary research. As such, all research projects include active stakeholder involvement in as many aspects of projects as feasible. With an active network of partners across the state, the Mitchell Center can also assist investigators in connecting with appropriate stakeholders when needed.

The Maine WRRI Co-Directors serve on several state-wide and national boards and committees (e.g. Maine Water Utilities Association, New England Interstate Water Pollution

Control Commission, Penobscot River and Bay Institute, American Water Works Association, National Institutes for Water Research). These activities provide opportunities to promote relevant institute-sponsored research and education. It also provides a process for the Maine WRRI to actively collect information about stakeholder concerns and challenges for water resources in the state and region.

Finally, the Maine WRRI receives public inquiries on a regular basis. In general, inquiries are related to information on outcomes from funded projects or how new research may be focused on a topic of particular importance. Responding to these inquiries is a priority and we make every effort to help citizens find answers and solutions to their problems. Although most inquiries come from Maine, we have received requests from around the globe.

5. Other project outputs

Presentations

- 2016ME318B - Calhoun, AJK. Ecology and conservation of vernal pools. Annual meeting of the Lantrust Network, Topsham, Maine April 2017.
- 2016ME318B - Hoffmann, K. E. 2017. Ecology of Unisexual and Blue-Spotted Salamanders at Frog Pond. Presented to the Orono Land Trust Annual Meeting on March 31, 2017.
- 2016ME318B - Hoffmann, K. E. 2017. Vernal Pools for Me. A poster displayed in the lobby of the Maine Sustainability and Water Conference on March 30, 2017.
- 2016ME318B - Calhoun, A. J. K. 2017. Conserving Vulnerable Wetlands and Watersheds: a Portfolio Approach. Presented to the Maine Sustainability and Water Conference on March 30, 2017.
- 2016ME318B - Hoffmann, K. E. 2007. Vernal Pool Ecology. Presented to Downeast Audubon on March 23, 2017.
- 2016ME320B - Environmental Attitudes and Behaviors Course. (2016, May). Perceptions of metallic mineral mining in Maine. Class presentation at University of Maine's service learning class presentations, Orono, Maine.
- 2016ME320B - Morgan, A. (2016, September). Testimony of Andrew Morgan before the Board of Environmental Protection, Neither for nor against the proposed chapter 200: Metallic mineral exploration, advanced exploration and mining. Testimony presented at the Maine Board of Environmental Protection Public Hearing, Augusta, Maine.
- 2016ME320B - Morgan, A. (2016, December). Risk perceptions of metallic mineral mining in Maine. Thesis project proposal presented at the School of Forest Resources, Orono, Maine.
- 2016ME320B - Morgan, A. (2017, January). Public risk perceptions of metallic mineral mining in Maine: A mixed methods study. Abstract to present at the International Symposium on Society and Resource Management in Umeå, Sweden on June 19, 2017. Accepted.
- 2016ME319B - Warner, K.A., Saros, J.E. Variable responses in lakewater dissolved organic carbon to extreme precipitation events. Association for the Sciences of Limnology and Oceanography Annual Meeting. March 3, 2017, Honolulu, Hawaii.

- 2016ME319B - Warner, K.A., Saros, J.E., Teisl, M.F. Investigating the response of Maine's drinking water resources to extreme precipitation events. 24th Annual Harold W. Borns, Jr. Symposium. April 14-15, 2016, University of Maine, Orono, Maine
- 2016ME319B - Warner, K.A., Saros, J.E. Investigating the response of Maine's drinking water resources to extreme precipitation events. Maine Sustainability and Water Conference, March 29, 2016, Augusta, Maine

Proposal Submissions

- 2016ME320B - De Urioste-Stone, S. (Lead PI), Morgan, A. (Proposal Author). Travel to present grant proposal. University of Maine Graduate Student Government. February 9, 2017. Requested, $850; awarded partial funding, $425.
- 2016ME320B - De Urioste-Stone, S. (Lead PI), Morgan, A. (Proposal Author). 2017 Lee & Sunny Allen international experience travel scholarship. The School of Forest Resources, University of Maine. April 13, 2017. Requested, $700; awarded full funding.
- 2016ME320B - Olsen, A. MacRae, J. & De Urioste-Stone, S.M. 2017. "Attitudes and impacts of mining in Maine: A comparative study". Requested $36,314; proposal submitted to Water Resources Research Institute. (Unfunded).

Media Articles

- 2016ME320B - Shepherd, M. 2017. Why legislating mining in Maine is so hard, in one survey. News article from the Bangor Daily News. URL: http://stateandcapitol.bangordailynews.com /2017/04/25/ whylegislating-mining-in-maine-is-so-hard-in-one-survey/
- 2016ME320B - Simms, D. (2017, March). Mitchell Center mining project data to be submitted for legislative consideration. Press release from the Senator George J. Mitchell Center for Sustainability Solutions. URL: https://umaine.edu/mitchellcenter/category/news/

Vernal pools for me

Basic Information

Title:	Vernal pools for me
Project Number:	2016ME318B
Start Date:	3/1/2016
End Date:	2/28/2018
Funding Source:	104B
Congressional District:	2
Research Category:	Not Applicable
Focus Category:	Education, Wetlands, Ecology
Descriptors:	None
Principal Investigators:	Aram Calhoun

Publications

There are no publications.

Project title Vernal Pools for Me

Investigators Aram J. K. Calhoun, Professor of Wetlands Ecology and Director of Ecology and Environmental Sciences, Department of Wildlife, Fisheries, and Conservation Biology, University of Maine, Orono, ME 04469-05775, (207) 581-3010, Calhoun@maine.edu

Kristine Hoffmann, post doctoral fellow, Department of Wildlife, Fisheries, and Conservation Biology, University of Maine

Information Transfer Project

1. Summary

The *Vernal Pools for Me* project highlights and enhances the connection between stakeholders and their vernal pools by encouraging understanding of these special, small water resources through a portfolio of outreach materials. Primary school children will learn about the diversity of animals that use vernal pools and about conservation through songs and a hybrid coloring book and field guide. Middle school and high-school students will benefit from web-based videos. Lay people will benefit from easily accessible and engaging web-based outreach material such as social media and blogs. This interdisciplinary outreach project builds on knowledge and opportunities provided by (1) research conducted under the NSF EPSCoR Sustainability Solutions Initiative and NSF CNH *Of Pools and People* grant on community based conservation of pools, (2) the Special Area Management Plan (SAMP) for the New England Region of the Army Corps of Engineers created by the Vernal Pool Streamlining Working Group to put pool conservation in the hands of local people, and (3) a $105,000 Environmental Protection Agency grant (a second has been submitted for another 2-yr funding cycle).

With the growth of social media, many conservation organizations now reach their audiences both on-site and in their own homes. For example, such groups such as Hirundo Wildlife Sanctuary and North East Partners in Amphibian and Reptile Conservation reach their stakeholders through field trips, seminars, and volunteer programs, but are increasingly following their audiences home through mobile and computer-based outreach. We seek to provide our partners with engaging material that they can use to educate their audiences through social media.

Expected deliverables

- Vernal pool coloring field guide for children
- Song(s) for children about vernal pools
- YouTube videos about vernal pool animals, the scientific process, and methods used to study vernal pools
- Blog posts by our partners describing their experiences with vernal pools
- Web comic describing the life cycle of vernal pool amphibians (see our first posts of the comic strip on vernalpools.me).

- Other deliverables identified based on the needs of stakeholders
- A one-page coloring flyer advertising the above for distribution to libraries and other public locations

2. Problem and Information Transfer Objectives

There are limited materials available for educators, children, and lay people wanting to learn about vernal pools. The Vernal Pool Associated has produced some printed materials and hosts vernal pool workshops for educators in Massachusetts, and 4H recently created vernal pool kits for educators in Maine, but these material are not readily available to the lay person and educators in other northeastern states. We plan to create multi-media deliverables that can be used in the classroom, home, and/or field by anyone, anytime, anywhere to learn about these important ecosystems.

Our Objectives are to

- Identify educational and outreach needs with stakeholders
- Create a portfolio of outreach materials about vernal pools for a variety of ages and audiences to incorporate into the Of Pools and People web site
- Host and solicit feedback on products from high school students
- Provide final deliverables online and in print

3. Methodology

Much of our project has been delayed due to the demands of manuscript preparation and graduation of our key PI defending her dissertation. We have completed 95% of our-web comic to date and 50% of filming for our YouTube videos. The comic is so successful, PI Calhoun has hired the undergraduate artist to produce comics on two more vernal pool species.

Our web comic (http://www.vernalpools.me/comic/) was developed by undergraduate artist, Laura Bollert, throughout the past year, and is now being released weekly online. Bangor High School's environmental science class provided feedback on the comic. This and other web-based deliverables are posted on the Of Pools and People website: http://www.vernalpools.me. The site also hosts the NSF-CNH research, the Maine Vernal Pool and Mapping Assessment Program, and will showcase the first two towns, Orono and Topsham, to implement the newly approved federal Vernal Pool Special Area Management Plan. Our consultant has expanded this website to include our materials.

We will continue our work in the fall of 2017 by visiting with school teachers, members of local land trusts, citizen scientists, personnel involved in SAMP in Orono and Topsham, and our web programmer, Shannon Homola, to tailor our efforts to make deliverables most useful to our audience. YouTube videos will be scripted to highlight science as a process, techniques used to study wetlands, and the biology and ecology of vernal pool animals. They will be filmed in the field and edited before being uploaded to social media. A personal service contract will be given to our singer/song-writer who will provide us with a digital recording to match with footage

from the field and posted to YouTube. Blogs will be composed from interviews with various stakeholders to highlight diverse view points on vernal pool issues.

4. Principal Findings and Significance.

- **What problem in sustainability has your research addressed?**
  The current Maine vernal pool regulations are a compromise of political and practical constraints and the best available science determining the needs of vernal pool indicator animals. While these are the most progressive vernal pool regulations in the country, these regulations have been challenged every regulatory session since 2007 and are not sufficient to ensure healthy populations of amphibians for future generations. We seek to promote understanding of vernal pools through education so the public may better understand the reasoning behind our legislation and better appreciate these unique wetlands. With this understanding, town citizens may be interested in pursuing local tools for conservation of vernal pool landscapes using the VP SAMP.

- **To what extent has your research helped implement a solution to this problem?**
  We have released 3 comics in our weekly series to date. The first week's comic has already reached 1,003 people on Face Book with 81 reactions, comments, and shares, and has 119 post clicks. It has been retweeted 8 times on Twitter and has 11 likes on that platform. Our social media consultant reports that "Comparing the comic to other posts we have done, the comics are getting quite a bit more engagement."

- **What roles have stakeholders played in your project's researcher-stakeholder partnership?**
  Some of our partners have provided feedback on our web comic and have shared it through social media. We visited Joyce Harrison's environmental science class at Bangor High School and received feedback from the students on the legibility, character development, clarity, and level of engagement of the comic. The students were learning from the comic as they gave feedback; for example, they told us that they would now recognize amphibian eggs when they found them in the woods. We solicited feedback from Mary Beth Kolozsvary, the leader of the Northeast Partners in Amphibian and Reptile Conservation's Vernal Pool Working Group. This group has shared the debut of the comic with their partners, including those who involves in outreach through zoos, schools, and nature centers. The Foundation for Salamander Conservation and the Mitchell Center have also shared our work through social media.

  We have worked with the Coastal Mountains Land Trust, Stillwater Montessori School, and Hirundo Wildlife Refuge to produce footage for our YouTube Videos. We filmed vernal pools and their biodiversity in natural settings, and also filmed both children and adults learning about vernal pools.

As our project continues, we are and will be discussing needs with various partners in preparation for developing the majority of our products. Amanda Shearin, from Maine's Department of Inland Fisheries and Wildlife, is seeking suggestions from peers who do outreach, and asked us to focus on the diversity of animals at vernal pools. We will discuss materials for young children with Joanne Alex of the Stillwater Montessori School this weeks as her class joins us for a vernal pool field trip.

- **How has this grant positioned you for future research funding and partnerships?** This grant is allowing us to demonstrate our ability to produce high quality outreach material. We will soon have a portfolio that we can show future funders when we apply for grants. We have found it easy to approach stakeholders and ask about what needs they have when they know that we will be proving them with digital and printed material.

Other Required Documentation

Student Support: Larua Bollert is a graduating senior in the Wildlife, Fisheries, and Conservation Biology Department. She has previously worked extensively with vernal pools though internships for two graduate students in our lab. Laura is also an amazing artist, and used her skills to illustrate our web comic. She used Photoshop and a drawing tablet, both of which she learned to use for this project. We worked with her to develop the plots of each comic, showed her how to tell the story in few panels, and how to write dialogue. We were surprised to learn of a generation gap, where she did not grow up reading the Sunday comics and so needed more help in understanding how to put one together. She came with me to Bangor High School to get an early critique of her work, and participated in asking the students questions and seeking feedback. We believe that showcasing her work through the comic may create other opportunities for her in the future.

Abigail Feuka and Karla Boyd also worked on this project in their senior year in the Wildlife, Fisheries, and Conservation Biology Department. Abbey was part of the vernal pool team for three years and has extensive knowledge of this ecosystem. She is one of the rare undergraduate students to be publishing a peer-reviewed research article (with Hoffmann, Calhoun, and Hunter). Karla had volunteered on the project, and was a hobby photographer. Abbey lead a public talk for the Coastal Mountains Land Trust in 2016, which we filmed for our You Tube Videos. Karla had limited videography knowledge, and we provided her with instruction to improve her skills. She also filmed vernal pool animals in a natural setting for us on other excursions.

Notable awards and achievements:

This work has contributed to Kris Hoffmann's receiving the Edith Patch Award for Distinguished Graduate Work in Science, Agriculture, Engineering, or Environmental Education as well at the Department of Wildlife, Fisheries, and Conservation Biology's Outstanding Graduate Student Program.

Presentations:

A slide advertising the web comic has been included in the following presentations

Calhoun, AJK. Ecology and conservation of vernal pools. Annual meeting of the Lantrust Network, Topsham, Maine April 2017.

Hoffmann, K. E. 2017. Ecology of Unisexual and Blue-Spotted Salamanders at Frog Pond. Presented to the Orono Land Trust Annual Meeting on March 31, 2017.

Hoffmann, K. E. 2017. Vernal Pools for Me. A poster displayed in the lobby of the Maine Sustainability and Water Conference on March 30, 2017.

Calhoun, A. J. K. 2017. Conserving Vulnerable Wetlands and Watersheds: a Portfolio Approach. Presented to the Maine Sustainability and Water Conference on March 30, 2017.

Hoffmann, K. E. 2007. Vernal Pool Ecology. Presented to Downeast Audubon on March 23, 2017.

Proposal Submissions:

In 2016 we applied for a $5,000 grant from the Foundation for Salamander Conservation, and received $500 to purchase the drawing tablet.

USGS Summer Intern Program

None.

Student Support					
Category	**Section 104 Base Grant**	**Section 104 NCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	4	0	0	0	4
Masters	2	0	0	0	2
Ph.D.	2	0	0	0	2
Post-Doc.	0	0	0	0	0
Total	8	0	0	0	8

Notable Awards and Achievements

Brett Gerard, Ph.D. student - Awarded a fellowship with the National Academy of Science's Gulf Research Program.

Kris Hoffmann, Ph.D. student - Received the Edith Patch Award for Distinguished Graduate Work in Science, Agriculture, Engineering, or Environmental Education

Kris Hoffmann, Ph.D. student - Received the Department of Wildlife, Fisheries, and Conservation Biology's Outstanding Graduate Student Award

Kelli M. Straka, M.S. student – First place, Graduate Student Poster Competition, 2016 Maine Sustainability & Water Conference

Brett Gerard, Ph.D. student – Honorable Mention, Graduate Student Poster Competition, 2016 Maine Sustainability & Water Conference

Publications from Prior Years

1. 2014ME305B ("Connecting climate and land use to Sebago Lake drainage network processes") - Other Publications - Smith, Sean; Brett Gerard, Chris Peterson, Andrew Bradford, and Brian Henkel. 2016. The Hydrologic Signature of Acadia National Park. Poster presentation, Acadia Science Symposium, Winter Harbor, Maine, October, 2016.
2. 2014ME305B ("Connecting climate and land use to Sebago Lake drainage network processes") - Other Publications - Gerard, Brett. 2016. Connecting Watersheds Characteristics and Drainage Network Processes in Coastal and Central Maine. Poster presentation, Maine Sustainability & Water Conference, March 30, 2016, Augusta, ME.
3. 2015ME313B ("Water budget, groundwater exchange and hydrologic variability of central Maine") - Other Publications - Straka, Kelli M. 2016. Quantifying groundwater exchange and variability of hydrologic fluxes in New England vernal pools. Poster presentation, Maine Sustainability & Water Conference, March 30, 2016, Augusta, ME.
4. 2009ME172B ("A sequential time-weighted average monitoring approach for monitoring pesticide levels in Maine surface waters.") - Dissertations - Charlestra, Lucner, "A Sequential, Time-Weighted Average Approach for Monitoring Pesticides in Maine Surface Waters" (2011). Electronic Theses and Dissertations. 1252. http://digitalcommons.library.umaine.edu/etd/1252
5. 2009ME172B ("A sequential time-weighted average monitoring approach for monitoring pesticide levels in Maine surface waters.") - Articles in Refereed Scientific Journals - Charlestra, L., A. Amirbahman, D.L. Courtemanch, H. Patterson. 2012. Estimating pesticide sampling rates by the polar organic chemical integrative sampler (POCIS) in the presence of natural organic matter and varying hydrodynamic conditions. Environmental Pollution 169:98-104. June 2012.
6. 2008ME176B ("Sustainable water allocation and rulemaking for Maine's surface waters: Adaptation consideration in a changing climate") - Articles in Refereed Scientific Journals - Sen Gupta, A., S. Jain, and J.-S. Kim (2011), Past climate, future perspective: An exploratory analysis using climate proxies and drought risk assessment to inform water resources management and policy in Maine, USA. Journal of Environmental Management, 92, 941-947. doi:10.1016/j.jenvman.2010.10.054
7. 2008ME176B ("Sustainable water allocation and rulemaking for Maine's surface waters: Adaptation consideration in a changing climate") - Dissertations - Sen Gupta, Avirup, "Hydrologic Variability and Change in the New England Region, USA" (2010). Electronic Theses and Dissertations. 11. http://digitalcommons.library.umaine.edu/etd/11
8. 2009ME171B ("Using Fluorescence Spectroscopy as a Rapid, Cost-Effective Method to Monitor and Analyze Low Levels of Pharmaceuticals in Three Maine Rivers.") - Other Publications - Killarney, J. 2009. Fluorescence Spectroscopy as a Rapid, Cost-Effective Method to Monitor and Analyze Low Levels of Pharmaceuticals and Personal Care Products in Environmental Water Samples. June 11, 2009. Poster. Society of Environmental Toxicology and Chemistry (SETAC) North Atlantic Chapter 15th Annual Meeting.
9. 2009ME188B ("Influences of dissolved organic carbon and iron on phosphorus photochemistry in surface waters") - Dissertations - Johnson, Dustin J., "Influences of Dissolved Organic Carbon, Iron, and Aluminum Photochemistry on Phosphorus Cycling in Fresh Surface Waters" (2010). Electronic Theses and Dissertations. 750. http://digitalcommons.library.umaine.edu/etd/750
10. 2009ME192B ("Citizen Science: Solving Groundwater Issues in New England") - Dissertations - Straub, Crista L., "Pro-Environmental Behavior Change: Solving Groundwater Issues in New England" (2012). Electronic Theses and Dissertations. 1812. http://digitalcommons.library.umaine.edu/etd/1812
11. 2009ME193B ("Impacts of White Perch Introductions on Trophic Dynamics: Paleolimnological Record of Zooplankton Grazing and Nutrient Cycling") - Dissertations - Ditzler, Kristin Elizabeth, "Effects of White Perch Introductions on Food Web Dynamics: Combining Paleolimnological and Whole-Lake Biomanipulation Approaches" (2010). Electronic Theses and Dissertations. 1140.

http://digitalcommons.library.umaine.edu/etd/1140

12. 2010ME201B ("Estimation of benthic dissolved organic carbon flux from wetland sediments using a novel technique") - Dissertations - Swett, Michael P., "Assessment of Benthic Flux of Dissolved Organic Carbon in Estuaries Using the Eddy Correlation Technique" (2010). Electronic Theses and Dissertations. 13. http://digitalcommons.library.umaine.edu/etd/13
13. 2010ME204B ("Permaculture Design Research Initiative") - Dissertations - Giordano, William, "Agriculture as Art" (2012). Electronic Theses and Dissertations. 1847. http://digitalcommons.library.umaine.edu/etd/1847
14. 2010ME214B ("Fish Scales as Non-Lethal Biosensors of Surface Water Contaminants ") - Dissertations - Skall, Daniel Gerhard, "Detecting Exposure to Surface Water Contaminants Non-lethally Using Atlantic Salmon (Salmo salar) Scales" (2011). Electronic Theses and Dissertations. 1246. http://digitalcommons.library.umaine.edu/etd/1246
15. 2010ME227B ("Atlantic salmon (Salmo salar) as an indicator of habitat quality in tributaries") - Dissertations - Ashe, Wesley Craig, "First-Summer Survival and Growth of Juvenile Atlantic Salmon in Headwater Streams: Implications for Restoring Connectivity at Road Culverts" (2012). Electronic Theses and Dissertations. 1849. http://digitalcommons.library.umaine.edu/etd/1849
16. 2010ME228B ("Microorganisms that can alter groundwater chemistry in an arsenic enriched aquifer") - Dissertations - Weldon, Jennifer M., "Correlations between Arsenic in Maine Groundwater and Microbial Populations as Determined by Fluorescent In-Situ Hybridization" (2005). Electronic Theses and Dissertations. 855. http://digitalcommons.library.umaine.edu/etd/855
17. 2012ME264B ("Photocatalytic Degradation of Pharmaceuticals and Personal Care Products (PPCPs) in Natural Water using Silver-Doped Zeolites") - Dissertations - Pan, Zhong, "Photocatalytic Removal of Pharmaceutical Compounds from Water Using TiO -Doped Zeolites" (2014). Electronic Theses and Dissertations. 2186. http://digitalcommons.library.umaine.edu/etd/2186
18. 2012ME282B ("Improving Data to Build Trust for Community Generated Knowledge of Groundwater.") - Dissertations - Thornton, Teresa E., "Human Dimensions of a School-Centered, Community-Based Environmental Monitoring Research (CBEMR) Project Focused on Private Drinking Water Wells in New England" (2011). Electronic Theses and Dissertations. 1300. http://digitalcommons.library.umaine.edu/etd/1300
19. 2012ME276B ("Analyzing Legacy Data in a Climate Context to Decipher Modern Changes in Lakewater Chemistry") - Dissertations - Strock, Kristin E. D., "Deciphering Climate-Mediated Changes in Boreal Lake Ecosystems" (2013). Electronic Theses and Dissertations. 2057. http://digitalcommons.library.umaine.edu/etd/2057
20. 2012ME276B ("Analyzing Legacy Data in a Climate Context to Decipher Modern Changes in Lakewater Chemistry") - Articles in Refereed Scientific Journals - Strock, K.E., S.J. Nelson, J.E. Saros, J.S. Kahl, S.D. Birkel, W. McDowell. 2016. Extreme weather years drive episodic changes in lake chemistry: Implications for recovery from sulfate deposition and long-term trends in dissolved organic carbon. Biogeochemistry 172(2). January 2016.
21. 2013ME293B ("Optimized Pre-Treatment for Fluorescence Monitoring of Surface Fresh Water Contamination") - Dissertations - Ahern, John C., "Photophysical and Photochemical Investigations of Novel Catalysts and Tunable Energy Transfer Systems" (2015). Electronic Theses and Dissertations. 2300. http://digitalcommons.library.umaine.edu/etd/2300
22. 2013ME294B ("Assessing threats of changing climate to drinking water quality") - Articles in Refereed Scientific Journals - Brown, R.E., Saros, J.E., Nelson, S.J. 2016. Paleolimnological evidence of the consequences of recent increased dissolved organic carbon (DOC) in lakes of the northeastern USA. Journal of Paleolimnology. November 2016.
23. 2015ME313B ("Water budget, groundwater exchange and hydrologic variability of central Maine") - Other Publications - Straka, Kelli and Andrew S. Reeve. 2015. Spatial and temporal assessment of hydrologic processes of New England vernal pools. Geological Society of America Abstracts with Programs (Baltimore, Maryland), 47(7):51-7

24. 2009ME172B ("A sequential time-weighted average monitoring approach for monitoring pesticide levels in Maine surface waters.") - Articles in Refereed Scientific Journals - Charlestra L., D.L. Courtemanch, A. Amirbahman, and H. Patterson, “Semipermeable membrane device (SPMD) for monitoring dioxin levels from a paper mill effluent in the Androscoggin River, Maine, USA.” Chemosphere, 2008, 72, 1171-1180
25. 2008ME171B ("Using Fluorescence Spectroscopy as a Rapid, Cost-Effective Method to Monitor and Analyze Low Levels of Pharmaceuticals in Three Maine Rivers.") - Dissertations - Killarney, James P., "Luminescence Methods to Quantify and Characterize PPCPs and VOCs in Natural Systems" (2013). Electronic Theses and Dissertations. 2003.
26. 2010ME201B ("Estimation of benthic dissolved organic carbon flux from wetland sediments using a novel technique") - Other Publications - Swett M.P., A. Amirbahman, and E. Boss, “Measurement of benthic dissolved organic carbon flux using eddy-correlation.” Poster presentation. Maine Water Conference, Augusta, ME, March 2010.
27. 2012ME264B ("Photocatalytic Degradation of Pharmaceuticals and Personal Care Products (PPCPs) in Natural Water using Silver-Doped Zeolites") - Articles in Refereed Scientific Journals - Pan, Z., E.A. Stemmler, W. Fan, L.A. Leblanc, H.H. Patterson, and A. Amirbahman, “Photocatalytic degradation of 17 -ethinylestradiol (EE2) in the presence of TiO2-doped zeolite.” Journal of Hazardous Materials, 2014, 279, 17-25.
28. 2012ME264B ("Photocatalytic Degradation of Pharmaceuticals and Personal Care Products (PPCPs) in Natural Water using Silver-Doped Zeolites") - Other Publications - Zhong P., A. Amirbahman, and H. Patterson, “Photocatalytic activity of TiO2-doped zeolite in the removal of 17 a-ethinylestradiol (EE2) in water.” Poster presentation. Maine Water Conference, Augusta, ME, March 2013.
29. 2012ME264B ("Photocatalytic Degradation of Pharmaceuticals and Personal Care Products (PPCPs) in Natural Water using Silver-Doped Zeolites") - Other Publications - Zhong P., A. Amirbahman, and H. Patterson, “Photocatalytic decomposition of pharmaceuticals and personal care products (PPCP) in natural water using silver-doped zeolites.” Poster presentation. Maine Water Conference, Augusta, ME, March 2012
30. 2012ME272B ("Maine Salt Management Scoping Project") - Other Publications - Hutchins, K., L.Thornbrough, L. Finnemore, B. Arter, B. Zollitsch, L. Lindenfeld. 2013. Maine Salt Management Taskforce Scoping Project. Technical report, August 2013.