A Social-Ecological Examination of Moose in Maine: Habitat, Management, and Changing Seasonality

Asha DiMatteo-LePape

University of Maine, asha.dimatteolepape@maine.edu

Follow this and additional works at: https://digitalcommons.library.umaine.edu/etd

Part of the Environmental Studies Commons, and the Other Ecology and Evolutionary Biology Commons

Recommended Citation


This Open-Access Thesis is brought to you for free and open access by DigitalCommons@UMaine. It has been accepted for inclusion in Electronic Theses and Dissertations by an authorized administrator of DigitalCommons@UMaine. For more information, please contact um.library.technical.services@maine.edu.
A SOCIAL-ECOLOGICAL EXAMINATION OF MOOSE IN MAINE:
HABITAT, MANAGEMENT, AND CHANGING SEASONALITY

By
Asha DiMatteo-LePape
B.S. University of Maine, 2019

A THESIS
Submitted in Partial Fulfillment of the
Requirements for the Degree of
Master of Science
(in Forest Resources)

The Graduate School
The University of Maine
August 2021

Advisory Committee:
Sandra De Urioste-Stone, Associate Professor of Nature-based Tourism, Co-Advisor
Sabrina Morano, Assistant Research Professor of Wildlife, Co-Advisor
John Daigle, Professor of Forest Recreation Management
A SOCIAL-ECOLOGICAL EXAMINATION OF MOOSE IN MAINE:
HABITAT, MANAGEMENT, AND CHANGING SEASONALITY

By Asha DiMatteo-LePape

Thesis Advisors: Dr. Sandra De Urioste-Stone and Dr. Sabrina Morano

An Abstract of the Thesis Presented
in Partial Fulfillment of the Requirements for the
Degree of Master of Science
(in Forest Resources)
August 2021

Maine is a New England state with rich ecosystems and diverse opportunities for enjoying the outdoors. Maine is well known as a popular nature-based tourist destination, and is often associated with its notable moose population. Social-ecological systems in Maine are highly intertwined, and as such, are especially susceptible to impacts resulting from climate change. Moose health in the state is already being negatively impacted by climate change with high infestation rates of winter tick resulting in declining moose health and high moose calf mortality. Given that late winter is a time of high stress and increased mortality of moose due to low resource availability, high energy use, and higher winter tick infestation; understanding winter habitat selection of moose in the context of changing winter weather conditions will be essential in determining how climate change will impact moose landscape use in Maine. Wildlife management is a key mechanism in moderating the relationship between people and wildlife, addressing wildlife diseases and parasites, and maintaining wildlife habitat. Moose management in Maine is essential for maintaining a healthy moose population, providing moose hunting and viewing opportunities, and reducing moose-vehicle collisions. Moose management in Maine is conducted by the Maine Department of Inland Fisheries and Wildlife (MDIFW) and the Wabanaki tribes; policy and management decisions can be guided by stakeholder perceptions and attitudes toward management strategies since part of managing wildlife is meeting the needs and desires of people. This thesis explores the human-moose social-ecological system in Maine with a transdisciplinary approach, and employs a participatory approach to
understand the effects of climate change on a social-ecological system to develop related solutions in a tourism dependent community. The aim of this research is to better understand moose landscape use in the context of changing winters, as well as perceptions and support of management strategies addressing moose parasitism in Maine. This thesis has three components: (1) characterization of winter habitat of adult moose; (2) survey of outdoor recreationists; and (3) participatory climate change planning. First, we identified winter habitat selection of adult female moose over the course of six years to explore the potential influence of winter weather and forest composition on moose landscape use. We found that moose selected forested areas to a greater extent than other land cover classes and selected all forest types, deciduous, evergreen, and mixed, equally. We found no influence of snow depth on these mature forest types; however, our results demonstrated increased selection of regenerating forests in years with lower snow density. These results have implications for moose distribution on the winter landscape, and impacts on regenerating forests in Maine and winter weather conditions continue to vary because of climate change. Second, we conducted a survey of moose hunters (in-state and out-of-state) and Maine recreationists to better understand perceptions of moose health, attitudes towards various management strategies, and confidence in MDIFW management efforts. We explored if differences between moose hunters, non-moose hunters, and non-hunters existed in terms of perceptions of moose health in Maine as well as their potential support of specific moose management strategies. We found that beliefs about moose health in Maine were largely moderate, and there was no difference in concerns about moose and winter tick parasitism among groups. Moose hunting was seen as an important part of managing a healthy moose population among all groups. Moose hunters were found to be the most comfortable with increasing moose hunting to reduce parasitism, followed by non-moose hunters. There was no statistically significant difference between groups regarding whether increasing moose hunting to reduce parasitism would have a strong positive or strong negative impact on moose population health. Intention to support moose hunting as a management strategy was neutral with no difference among groups. Confidence in agency management was statistically different between non-hunters and moose hunters, and between non-hunters and non-moose hunters. Self-reported feelings of being up to date on information regarding
current moose population health and management was different among all groups, with moose hunters reporting being the most up to date. Further, understanding the impacts and perceptions of climate change needs to be paired with action in order to adapt to changes and promote resilient social-ecological systems. The final research component of this thesis was the joint development and implementation of a series of participatory planning workshops on community climate change adaptation and mitigation. The participatory process used reinforced the idea that collaborative planning and stakeholder driven solution development are key to identifying locally relevant priorities and feasible action steps. There are many social-ecological systems in Maine that are vulnerable to climate change, including the human-moose system; hence, interdisciplinary approaches that integrate biophysical and social science research efforts are essential to addressing impacts to these complex systems into the future.
ACKNOWLEDGEMENTS

I would like to thank my co-advisors, Dr. Sandra De Urioste-Stone and Dr. Sabrina Morano, for your endless support, encouragement, and feedback. Thank you for all of your time and guidance. I would like to thank Dr. John Daigle for his support as a member of the thesis committee and for sharing your expertise with me. I would also like to thank Lee Kantar, Craig McLaughlin, and the Maine Department of Inland Fisheries and Wildlife for their collaboration and feedback, this work would not have been possible without you.

I am deeply grateful for the support and opportunity to work closely with Lydia Horne, Alyssa Soucy, Valeria Briones, and Gabriela Wolf-Gonzalez as the Shifting Seasons team; your enthusiasm, feedback, and encouragement made this work possible. I would like to extend a big thank you to my lab groups for all of their support, both academic and otherwise: Elizabeth Pellecer Rivera, Sarah Rappaport, MacKenzie Conant, Alyssa Campbell, Michelle de Leon, Neil Clayton, Gabrielle Hillyer, Cynthia Houston, Jeffrey Rodriguez, and Gabrielle Sherman.

This research was made possible through generous support and collaboration with the Maine Department of Inland Fisheries and Wildlife. This work was supported by the USDA National Institute of Food and Agriculture, McIntire Stennis project number #ME0-42017 through the Maine Agricultural & Forest Experiment Station and by the National Science Foundation under Grant No. 1828466.

I would like to thank all of the tourism partners and workshop attendees, without whom there would be no chapter four. These workshops were funded by the University of Maine Senator George J. Mitchell Center for Sustainability Solutions. Additional funding to support student researchers came from the NSF-NRT Conservation Science Program (grant 1828466), NOAA (grant NA17OAR4310249), USDA-NIFA (McIntire-Stennis project number ME0-42017), the USDA-AFRI Agriculture and Natural Resources Science for Climate Variability and Change (AFRI ANRCVC) Challenge Area Program (grant 2018-69002-27933), the UMaine Office of the President, and the UMaine Department of Ecology and Environmental Sciences.
TABLE OF CONTENTS

ACKNOWLEDGEMENTS ........................................................................................................... ii
LIST OF TABLES .................................................................................................................... vii
LIST OF FIGURES ................................................................................................................... ix

CHAPTER 1: INTRODUCTION ................................................................................................. 1
1.1. Study area ....................................................................................................................... 2
1.2. Methodological approach .............................................................................................. 4
1.3. Research questions ......................................................................................................... 5
1.4. Research justification ..................................................................................................... 5
1.5. Organization of thesis .................................................................................................... 7

CHAPTER 2: WINTER HABITAT SELECTION OF MOOSE IN MAINE AND IMPLICATIONS OF
CHANGING WINTER CONDITIONS ...................................................................................... 8
2.1. Introduction ................................................................................................................... 8
2.2. Study area ..................................................................................................................... 11
2.2. Methods ......................................................................................................................... 13
   2.3.1. Moose locations ..................................................................................................... 13
   2.3.2. Home range generation .......................................................................................... 14
   2.3.3. Environmental variables ....................................................................................... 14
   2.3.4. Statistical analysis .................................................................................................. 16
2.4. Results ........................................................................................................................... 17
   2.4.1. Resource selection .................................................................................................. 20
2.4. Discussion ....................................................................................................................... 24

CHAPTER 3: PERCEPTIONS OF MOOSE IN MAINE AND POTENTIAL SUPPORT OF
INCREASED MOOSE HUNTING AS A MANAGEMENT STRATEGY IN MAINE ................. 29
3.1. Introduction .................................................................................................................... 29
3.2. Significance

3.3. Conceptual framework

3.3.1. Cognitive hierarchy model of human behavior

3.3.2. Theory of Planned Behavior

3.3.3. Perceived risk

3.4. Methods

3.4.1. Study site

3.4.2. Survey design and sampling

3.4.3. Survey instrument

3.4.5.1. Confidence in agency and current knowledge

3.4.5.2. Risk perceptions

3.4.4. Survey quality

3.4.6. Data management and analysis

3.5. Results

3.5.1. Sample characteristics

3.5.2. Perceptions of moose in Maine

3.5.3. Assessment of moose hunting as a management strategy

3.5.4. Attitudes and behavior intentions towards management strategies

3.5.5. Confidence in agency and current knowledge

3.5.6. Risk perceptions of moose health in Maine

3.6. Discussion

3.6.1. Limitations and future research

CHAPTER 4: CLIMATE CHANGE PLANNING IN A COASTAL TOURISM DESTINATION, A PARTICIPATORY APPROACH

4.1. Introduction

4.1.1. Climate change, visitation, and tourism supplier adaptation
4.1.2. Participatory workshops for climate change planning ................................................. 59

4.2. Methods .......................................................................................................................... 60

4.2.1. Study area .................................................................................................................. 60

4.2.2. Workshop planning and implementation ..................................................................... 62

4.2.2.1. Workshop 1 .......................................................................................................... 63

4.2.2.2. Workshop 2 .......................................................................................................... 64

4.2.3. Data analysis .............................................................................................................. 65

4.3. Results ............................................................................................................................ 65

4.3.1. Workshop 1 .............................................................................................................. 65

4.3.1.1. Key patterns from workshop 1 ........................................................................... 67

4.3.2. Workshop 2 .............................................................................................................. 68

4.3.2.1. Key patterns from workshop 2 ........................................................................... 69

4.4. Discussion ...................................................................................................................... 70

4.4.1. Collaboration and communication across stakeholders ............................................ 71

4.4.2. Tipping points .......................................................................................................... 73

4.4.3. MDI’s opportunity to model sustainable tourism ....................................................... 74

4.4.4. Study limitations and future actions ....................................................................... 75

4.5. Conclusion ...................................................................................................................... 75

CHAPTER 5: CONCLUSION ..................................................................................................... 77

5.1. Integration of research ................................................................................................... 77

5.2. Future research .............................................................................................................. 80

5.3. Transdisciplinary research and the NRT ..................................................................... 81

5.4. Final thoughts ............................................................................................................... 81

REFERENCES ....................................................................................................................... 83

APPENDIX A: BIOPHYSICAL ANALYSIS SUPPLEMENTAL TABLES .................................. 106

APPENDIX B: SURVEY INSTRUMENT ................................................................................. 107
## LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 2.1</td>
<td>Composition of available landscape</td>
<td>17</td>
</tr>
<tr>
<td>Table 2.2</td>
<td>Matrix of correlation</td>
<td>19</td>
</tr>
<tr>
<td>Table 2.3</td>
<td>GLMM model results</td>
<td>20</td>
</tr>
<tr>
<td>Table 2.4</td>
<td>Model results from assessment of interaction between land class variables and yearly winter severity metrics</td>
<td>21</td>
</tr>
<tr>
<td>Table 2.5</td>
<td>Model beta estimates and standard errors</td>
<td>22</td>
</tr>
<tr>
<td>Table 3.1</td>
<td>Mean responses for key measures grouped by relationship with moose hunting</td>
<td>47</td>
</tr>
<tr>
<td>Table 3.2</td>
<td>Mean responses for risk perception measures grouped by relationship with moose hunting</td>
<td>51</td>
</tr>
<tr>
<td>Table 4.1</td>
<td>Overview of workshop objectives and activities conducted each day, and duration of each activity</td>
<td>62</td>
</tr>
<tr>
<td>Table 4.2</td>
<td>Ranking of climate change items by significance of their ability to impact tourism on MDI and easiest to address (top five rankings)</td>
<td>66</td>
</tr>
<tr>
<td>Table A.1</td>
<td>Ten-year winter weather variable trends averaged between WMD 8 and WMD 2</td>
<td>106</td>
</tr>
<tr>
<td>Table A.2</td>
<td>Sample size and average home range size per year for both WMD’s</td>
<td>106</td>
</tr>
<tr>
<td>Table I.1</td>
<td>Sociodemographics for the full sample and by group</td>
<td>137</td>
</tr>
<tr>
<td>Table I.2</td>
<td>Sociodemographics and means for the full sample and by group</td>
<td>138</td>
</tr>
<tr>
<td>Table J.1</td>
<td>Reported support for increasing moose hunting permits for female (cow) moose in order to address winter tick infestation</td>
<td>139</td>
</tr>
<tr>
<td>Table J.2</td>
<td>Perceived familiarity and knowledge of moose by Maine moose hunters and out-of-state moose hunters</td>
<td>139</td>
</tr>
<tr>
<td>Table J.3</td>
<td>Percent of moose hunter respondents likely to support an increased moose hunting management strategy based on justification</td>
<td>140</td>
</tr>
</tbody>
</table>
Table J.4.  Indices and internal consistency................................................................. 140
Table J.5.  Index intercorrelations. ............................................................................... 140
Table K.1.  Participant list of climate change impacts and opportunities for tourism on MDI.
........................................................................................................................................ 142
LIST OF FIGURES

Figure 1.1. Location of study area, Maine, in the context of the US and New England .......... 2

Figure 2.1. Location of study area, Wildlife Management Districts 2 and 8, in the context of US and Maine ......................................................................................................................................................... 13

Figure 2.2. Average winter snow depth (in) and average winter maximum temperature (F) from 2000-2019, including study period from 2013-2019, for WMD 2 and 8 ....... 18

Figure 2.3. GLMM odds ratio results and standardized beta estimates ........................................... 23

Figure 2.4. Resource Selection Functions (RSF), relative predictive probability of use for A) deciduous, evergreen, and mixed forest and B) regenerating forest as a function of snow density ......................................................................................................................................................... 24

Figure 3.1. Vaske & Donnelly (1999) Cognitive hierarchy model of human behavior .............. 35

Figure 3.2. Ajzen (2019) Theory of Planned Behavior ................................................................. 36

Figure 3.3. Word cloud depicting the relative frequency of different perceptions of the most concerning factor negatively impacting moose ................................................................................. 53

Figure 4.1. Location of study area, Mount Desert Island, in the context of US and Maine ..... 61
CHAPTER 1
INTRODUCTION

There are strong relationships between the environment, natural resource dependent communities, and nature-based tourism systems. This is especially true in Maine, U. S., where diverse landscapes, especially forests, and wildlife populations facilitate strong interactions between humans and nature, foster nature-based tourism development, and support many livelihoods both directly and indirectly. Moose (Alces alces americana Linnaeus, 1758) are an iconic species in Maine that are integrated into the state's culture and identity (Timmermann & Rodgers, 2005). Moose are part of Maine's image as a New England state and moose viewing and hunting contribute to Maine's tourism system (Auger, 2006). Given the social, cultural, ecological, and economic importance of moose to Maine, it is essential to understand the dynamics and changes in the moose socio-ecological system (SES).

Climate change introduces new challenges and opportunities to interconnected SES, such as the human-moose system in Maine. The impacts of climate change are becoming a major concern in Maine due to changes in biophysical processes that negatively impact ecological and social dynamics in the state (Fernandez et al., 2020). When it comes to the socio-ecological system of moose and people in Maine, there is a need to identify and understand how climate change will influence moose populations. Climate change is likely impacting moose health and population dynamics which has implications for Maine's ecological systems, rural communities, and nature-based tourism system.

Locally relevant planning and management are crucial when it comes to addressing the impacts of climate change in Maine (Pickets et al., 2012). Managing Maine's moose population for climate change impacts will be integral to maintaining a healthy population while also supporting the benefits that moose provide to the state including cultural significance, state identity and image, hunting opportunity, and economic benefits. Effective planning and management will rely on accurate information on how climate change is impacting moose, as well as how stakeholders are perceiving the state of the moose population and related management strategies to be used. The goal of this research is to increase our understanding of moose habitat selection in the context of climate change, assess stakeholder perceptions and attitudes.
toward moose management, and develop and assess participatory workshops as a method for community-based climate change planning in a nature-based tourism destination.

1.1 Study area

Maine is a state in northeastern New England in the United States (Figure 1.1). Maine is largely forested (Butler, 2018) and relies on its diverse natural resources for social, cultural, and economic resilience. Due to its diverse landscape and natural resources, Maine is a popular tourist destination with 37.4 million visitors coming to the state in 2019 alone (Maine Office of Tourism [MOT], 2019a). Tourism supported over 100,000 jobs and contributed over 6 billion dollars to the state in 2019 (MOT, 2019a). Nature-based tourism, a form of travel that is centered around nature and the outdoors, is highly popular in Maine (Munding & Daigle, 2007). Nature-based tourism and outdoor recreation in Maine include activities such as wildlife viewing and hunting.

Figure 1.1. Location of study area, Maine, in the context of the US and New England with county boundaries. (a) Tourism regions in Maine designated by the Maine Department of Transportation Explore Maine.
Maine has one of the largest moose populations in the lower 48 states with an estimated 76,000 moose in 2012 (Maine Dept. of Inland Fisheries and Wildlife, n.d.-c). With a big focus on hunting and other forms of nature-based tourism, moose have become integral to Maine’s culture and economy (LaBarbera, 2002). According to a report conducted on behalf of the Maine Office of Tourism and the Maine Department of Inland Fisheries and Wildlife (MDIFW), direct and indirect spending on moose hunting contributed over $20,800,000 to Maine in 2013 (Southwick Associates, 2014). This includes direct trip expenditures and hunting equipment, as well as jobs and income tied to this spending (Southwick Associates, 2014).

As a result of climate change, Maine is expected to experience an increase in temperatures and changes in precipitation patterns. The state is expected to experience more rain during the winter, earlier snow melt, and fewer days with snow on the ground (Fernandez et al., 2020; Rustad et al., 2012). These changes in seasonality have implications for Maine’s forest ecosystems through increases in invasive species, modifications in the phenology of plant species, and mismatches between food availability and species migratory timing (Rustad et al., 2012; United States Environmental Protection Agency, 2015). Recent literature has suggested that increases in temperature and interactions with other wildlife have resulted in increased parasitism in moose as a consequence of climate change (Ditmer et al., 2020; Malmsten et al., 2018; Weiskopf et al., 2019). Changing seasonal weather patterns resulting from climate change are likely influencing moose health, habitat selection, and the distribution of the species (Van Beest et al., 2012). There is a strong connection between moose and Maine culture, recreation and tourism, and the economy; hence, understanding how these wildlife-human relationships will be impacted by potential changes in the moose population will be critical to determining the scope of influence that changing seasonality could have on both moose and people in Maine.

Tourism in Maine is also expected to be impacted by climate change (Wilkins et al. 2018a). The impacts of climate change on tourism are complex and multifaceted. Hunting tourism is tied directly to the health and management of wildlife populations, which can be impacted by changing climate conditions. Nature-based tourism is influenced by the unpredictability of changing environmental
conditions and weather patterns, which can change how tourists interact with the Maine landscape, as well as their decision to visit Maine (De Urioste-Stone et al., 2015; McCreary et al., 2019; Perry et al., 2018). Weather conditions can influence tourist decision making and can influence where and when people visit a destination (Wilkins et al., 2018a). This dynamic can change tourist spending as well which can impact tourism destinations that rely on the economic benefits of visitors (Wilkins et al., 2018a). Visitors specifically engaging in nature-based tourism have been found to consider weather conditions as having a great deal of influence on their travel (Wilkins et al., 2018b), which has implications for how nature-based tourism could shift as climate change continues to impact Maine's weather conditions. Risk perceptions related to climate change are also likely to influence visitor behavior and decision making regarding nature-based tourism (Horne et al., 2021). Many communities in Maine rely on tourism, and climate change is introducing uncertainties into the relationships between the environment, Maine communities, and visitors.

1.2 Methodological approach

The transdisciplinary nature of this research required multiple data generation techniques and collaboration with conservation partners (Lang et al., 2012). Transdisciplinary research approaches involve multiple actors from within and outside of academia to integrate real-world solutions with rigorous scientific discovery (Lang et al., 2012). These approaches capitalize on the knowledge, values, and preferences of practitioners to combine scientific discovery with actionable solutions to pressing problems (Lang et al., 2012). We focused on three areas of research. First, to explore the impact of changes in winter weather conditions and forest composition on moose populations, we used spatial analysis and GPS location data to measure biophysical determinants of habitat selection (Chapter 2). Second, we employed a social science approach using a post-positivist paradigm (Henderson, 2011) to conduct a cross-sectional survey (Michaelson & Stacks, 2014; Visser et al., 2000) aimed at exploring perceptions of moose in Maine and attitudes toward moose management strategies in the state (Chapter 3). Lastly, we developed and implemented workshops utilizing participatory planning techniques (Galvin, 2019) to aid in community-based climate change and tourism planning efforts (Chapter 4).
1.3 Research questions

The overall goal of this research was to assess Maine's moose SES as it relates to the connections between the species and its habitat, climate change, outdoor recreationists perceptions and intended behaviors, and wildlife management. The following research objectives were outlined in order to achieve this overall goal:

i) Determine how forest composition and winter weather conditions influence moose winter habitat selection in Maine to establish an understanding of how moose winter habitat might be impacted by changing weather conditions as a result of climate change (Chapter 2).

ii) Explore beliefs about moose in Maine and risk perceptions related to moose population health (Chapter 3).

iii) Examine differences between moose hunters, non-moose hunters, and non-hunter Maine recreationists for key variables including (1) beliefs about the current moose population in Maine, (2) risk perceptions related to moose parasitism, (3) beliefs about moose hunting, (4) individual attitudes and behavioral intentions toward supporting specific moose management strategies, (5) confidence in the management agency, and (6) self-reported current knowledge of moose in Maine (Chapter 3).

iv) Develop and implement community-based climate change planning workshops to support locally relevant solutions and community action related to climate change and tourism in a nature-based tourism destination in Maine (Chapter 4).

1.4 Research justification

This research brings together ecological data, social science, and planning methods in order to address the complexities of understanding and addressing climate change in Maine's socio-ecological systems. Increasing our understanding of how moose habitat selection is influenced by weather conditions can inform policy and management objectives in order to promote population health as well as maintain strong relationships between people and moose. Moose management plays an important role in both moose health and socioeconomic relationships tied to moose (Ericsson, 2003).
Preliminary data gathered on the risk perceptions of moose-winter tick interactions in Maine suggests that stakeholders, namely hunters, moose hunting and viewing outfitters, and Wabanaki citizens, see moose hunting as a critical part of Maine culture, tourism, and a form of sustenance (DiMatteo-LePape, 2019; Elliott, 2019). Wabanaki citizens in Maine have a strong relationship with moose; the species has cultural significance, plays an important role in traditions, and contributes a key food source for Wabanaki people in Maine (DiMatteo-LePape, 2019; Elliott, 2019). Wabanaki cultures have many ties to moose, including creation stories centered around moose (Penobscot Indian Nation Cultural and Historic Preservation Department [PINAHPD], 2011), rites of passage that involve moose hunting (DiMatteo-LePape, 2019), and traditional crafts reliant on materials from moose (Kent, 2014). Further, changes in the ability to hunt moose will impact Maine hunting traditions, economic benefits from tourism, and cultural traditions (Timmermann & Rodgers, 2005). Hence, a greater understanding of stakeholder risk perceptions, confidence in management, and attitudes towards moose management strategies can help inform communication tools and stakeholder participation efforts by MDIFW. By better understanding how different groups, including moose hunters, non-moose hunters, and outdoor recreationists, perceive moose health and management, MDIFW can gain a more comprehensive understanding of the acceptability of specific moose management strategies by different stakeholder groups.

Knowledge surrounding moose landscape use and stakeholder perceptions of moose can help managers design wildlife management goals and objectives that take into account moose population dynamics, the values people have for moose, and perceptions of moose management in Maine. Understanding perceptions of, and confidence in, the MDIFW as a primary moose management entity in Maine, can also help the agency maintain its social license. Social license is the community support and consent for a business, or agency, to operate. In order to maintain the support of the public, wildlife management agencies need to understand the values that people have for wildlife and uphold expectations that people have for management (Hampton & Teh-White, 2019).

As climate change impacts become more drastic in Maine, nature-based tourism dependent communities will need strategies for planning for changes in both biophysical conditions and visitation
patterns. This research contributes to our understanding of community-based climate change planning as it relates to tourism and provides a framework for integrating key community stakeholders into the development of workshops that provide an opportunity to build shared understanding of community concerns and action strategies.

This research can inform future socio-ecological studies that seek to link conservation, tourism, and community planning both within and outside of Maine. Understanding how moose in Maine will be impacted by climate change, how stakeholders perceive these changes, and how community planning can be leveraged to develop solutions to climate change and tourism, will provide valuable insights for other social-ecological systems that rely on wildlife and tourism systems vulnerable to climate change impacts.

1.5 Organization of thesis

This thesis is organized into five chapters, three of which are intended as published journal articles. Chapter two outlines our analysis of moose winter home ranges in the context of changing winter weather conditions. This biophysical analysis utilized GPS location data and habitat selection modeling. This chapter is intended for publication in Alces.

In chapter three we present results from our survey of hunters and outdoor recreationists regarding perceptions of moose and attitudes toward management strategies. Results include risk perceptions related to moose health, attitudes toward moose hunting as a management tool, confidence in MDIFW management, and potential support of management strategies. This chapter will be submitted to Human Dimensions of Wildlife.

Chapter four consists of the results from a collaborative project to develop and implement community-driven climate change and tourism planning workshops aimed at identifying areas of concern and related strategies for actions to address these locally relevant concerns. This chapter is under review in the Journal of Environmental Planning and Management. The fifth and final chapter seeks to integrate chapters two through four and discuss the relevance of integrating research at multiple scales of a social-ecological system to contribute to climate change understanding and planning.
CHAPTER 2

WINTER HABITAT SELECTION OF MOOSE IN MAINE AND IMPLICATIONS OF CHANGING WINTER CONDITIONS

2.1 Introduction

Environmental conditions and available habitat are important drivers of moose (*Alces alces americana* Linnaeus, 1758) population dynamics, and influence the spatial and temporal distribution of the species within their geographic range (Leptich & Gilbert, 1989). Moose are found in the boreal forests of the northern hemisphere. Their distribution is limited by food and forest cover availability at the northern edge of their distribution, and climate, most importantly temperature, at the southern edge of their range (Karns, 1998). Similar to many northern regions, Maine has been experiencing shifts in climatic conditions, most notably climatic warming and extreme weather events resulting in warmer, shorter, and less snowy winters (Fernandez et al., 2020). These changes in conditions have the potential to greatly impact moose populations both directly, through changing weather conditions, and indirectly, through changes in disease dynamics and shifts in forest composition (Post & Stenseth, 1999).

Moose are a prominent species in New England. After a history of heavy hunting in the eighteenth century, their numbers have been increasing since the early 1900s. In Maine, the moose population was estimated to be between 30,000-60,000 individuals in 2010 with higher densities in the interior forests of the state (Wattles & Destafano, 2011). This population increase is thanks to a range of factors including the reconversion of farmland to forest, changes in forest management, and the regulation of moose hunting (Foster et al., 2002; Karns, 1998; Wattles & Destafano, 2011). The rebound of forested land in New England, along with forestry practices that provided a patchy mosaic of regenerating forest stands, dramatically increased the amount of moose habitat in Maine since regenerating forest stands provide ideal forage for moose due to their high biomass (Andreozzi et al., 2016; Christenson et al., 2014; Ditmer et al., 2018; Renecker & Schwartz, 1998; Van Beest et al., 2010; Wattles & Destafano 2011).

Climate change is expected to increase the northern range of many hardwood tree species that moose rely on for forage, including red maple (*Acer rubrum* L., 1753) and birch (*Betula sp.* L., 1753)
(Peterson et al., 2020; Rodenhouse et al., 2009). In Maine, maple-beech-birch forests are expected to remain the predominant forest type (Rustad et al., 2012). Whereas spruce-fir forests and lowland mixed conifer forests, which provide important moose cover and winter browse (Leptich & Gilbert, 1989; Ludewig & Bowyer, 1985), have been cited as being some of the most vulnerable species to climate change (Swanston et al., 2018).

In addition to influencing forest composition, climate change is also expected to have an impact on moose population health in Maine (Dunfey-Ball, 2017). Changes in winter severity (i.e., length of season and amount of snow accumulation), competition for resources, and related increases in disease and parasitism (Murray et al., 2006) pose threats to moose health. Milder winters can bring increased white-tailed deer (*Odocoileus virginianus* Zimmermann, 1780) density to areas in Maine with large moose populations (Weiskopf et al., 2019). Along with increased resource use, white-tailed deer can pass diseases like meningeal worm (*Parelaphostrongylus tenuis* Boev & Schultz, 1950) to moose (Lanester 2010, 2018; Murray et al., 2006). Another stressor to moose are winter ticks (*Dermacentor albipictus* Packard, 1869), a parasite that negatively impacts moose health (Healy et al., 2018; Samuel, 2007). In combination with severe winter weather, winter ticks have been cited as causing widespread mortality of moose calves as well as a recent decrease in adult cow productivity (Elliott, 2019; Jones et al., 2019; Musante et al., 2010). Changing climate conditions will alter the dynamics between moose and stressors including meningeal worm, winter tick, competition for resources, and environmental conditions (Jones et al., 2019; Murray et al., 2006; Weiskopf et al., 2019). Understanding how changes in weather conditions may influence winter habitat use by moose in Maine will provide important information regarding resource use and moose health. As such, it is critical to understand winter home range habitat selection and landscape use by moose in the context of changing winter conditions (Bjorneraas et al., 2011; Maier et al., 2005).

Moose select habitat to meet both foraging and cover needs in the winter, and generally select for food availability over forest cover habitat resources (Poole & Stuart-Smith, 2006; Renecker & Schwartz, 1998). Midwinter is a time of high stress for moose due to high energy demands and low food resources.
(Peek, 1998; Pekins, 2020; Schwartz & Renecker, 1998). As such, in some conditions moose will select habitat to conserve energy in the winter (Peek, 1998). In general, moose forage on woody plants, twigs, and fallen leaves in the winter (Renecker & Schwartz, 1998). This foraging favors Maple (*Acer sp.*) and other hardwood species, as well as Eastern Hemlock (*Tsuga canadensis* (L.) Carrière) and Balsam Fir (*Abies balsamea* (L.) Mill) (Faison et al., 2010; Ludweig & Boyer, 1985). Late winter conditions can greatly impact moose, especially moose calf survival (Cederlund et al., 1991), since this is the time of year when resources and individual fat reserves are the most limited (Cederlund et al., 1991; Pekins, 2020; Schwartz & Renecker, 1998). Individual survival and future reproduction is reliant on adequate forage and cover resources to withstand late winter weather conditions and additional pressure from diseases and parasites (Jones et al., 2019; Pekins, 2020; Schwartz & Renecker, 1998).

Overstory cover is required as protection from harsh winter conditions and deep snow accumulation (Dussault et al., 2005). Cover habitat consists of dense vertical tree canopy, generally softwood forest stands (Dussault et al., 2005). Snow depth and snow density, the mass of the snow compared to its volume (often reported as percent water content), can impede moose movement and limit access to forage; while moose are well adapted to traveling through the snow, snow depths greater than 70cm can negatively impact movement (Peek, 1998; Ballenberghe & Ballard, 1998). Low snow depth lessens the need for dense forest cover that provides areas of low snow accumulation during the late winter months (Courtois et al., 2002), and reduces the amount of energy required for foraging (Peek, 1998). Since moose respond to habitat variables within a few kilometers of their location (Maier et al., 2005), it is important to consider home range selection within the larger landscape.

Forest composition shifts due to climate change, as well as changing forest management decisions, coupled with decreasing annual snow depth and increasing winter temperatures, could change the way that moose interact with forest ecosystems (Humphries et al., 2004; Rodenhouse et al., 2009). By determining how forest composition and climatic variables, such as temperature and snow density, influence habitat selection, we can gain a better understanding of how predicted climatic changes in Maine will alter resource availability, moose responses to environmental conditions (Rodenhouse et al.,
2009), and moose distribution on the landscape (Humphries et al., 2004). Understanding moose winter landscape use as it relates to winter weather conditions will help inform the relationship between moose health and climate change impacts in Maine by providing insight into how home range scale habitat features are used by moose in different winter conditions and how moose landscape use and distribution in the state could change in the future.

By analyzing winter home ranges over the course of six years we were able to explore the potential influence of winter weather and forest composition on moose landscape use. We utilized Resource Selection Functions (RSF's) (Manley et al., 2002) to characterize winter habitat use in the context of changing winter conditions in Maine. The objectives of this study were to determine moose winter home range habitat selection in Maine, and explore how winter weather conditions influence landscape use through home range selection. We hypothesize that (1) during winter moose will select habitat features that minimize energy expenditure and maximize forage availability, and (2) changes in winter weather conditions will influence the extent to which moose interact with landscape features that provide cover and forage resources. If moose are selecting habitat to minimize energy expenditure over winter, we would expect to see selection for forest types that provide both winter forage and overstory cover such as mixed forests that consist of both hardwood and softwood species. We might also expect to see selection for mixed forests, which contain hardwood species such as Maples (Acer spp.) that comprise moose winter diet, and softwood species such as spruce (Picea spp.) and fir (Abies spp.), which provide overstory cover. If winter conditions are impacting habitat selection, we predict that there will be greater use of softwood stands in winters with greater snowfall, and conversely greater use of regenerating forests in winters with less snow accumulation on the landscape.

2.2 Study Area

Maine is located in the Northeastern United States and has a diverse landscape from rocky coast to interior mountains. The majority of the state, 89%, is forested (Butler, 2018) which affords a wide range of landscape characteristics. Maine's forest is composed mainly of maple-beech-birch forests, as well as spruce-fir and aspen-birch forests (Butler, 2018). Maine has over 6,000 lakes, 32,000 miles of
rivers and streams, and hundreds of square miles of wetlands (TNC, 2008). Our study area includes regions in Maine that have seen high levels of historical and current forest management and harvesting, and include both mature and regenerating forests (Wiersma, 2009). Historical forest harvesting in Maine favored larger clear-cuts that created a patchy forest landscape and led to regeneration driven by industry demands for certain tree species (Barton et al., 2012). This mosaic of forest disturbance and regeneration was altered by forest practice laws established in 1989 to reduce clear cut size and promote adequate regeneration, which led to a more even distribution of forest harvesting impacts and regenerating stands (Barton et al., 2012). Additional changes in landscape use occurred in the form of sustainable forestry initiatives and a dramatic increase in conserved lands beginning in the 1990s (Barton et al., 2012). Maine's forest structure today is still greatly influenced by forest harvesting practices that facilitate a range of different forest stand ages and compositions. These practices are also likely to influence moose landscape use by altering the composition and distribution of the forested landscape in Maine.

Maine is divided into 30 Wildlife Management Districts (WMD's) by the Maine Department of Inland Fisheries and Wildlife (MDIFW) in order to aid in wildlife management (Maine Dept. of Inland Fisheries and Wildlife, 2017). This study focuses on WMD 8 in the western Maine mountains, and WMD 2 in northern Maine (Figure 2.1). Both districts are located in the New England Adirondack Province ecoregion of Maine, with WMD 8 in the Central and Western Mountains region, and WMD 2 in the Boundary Plateau-St. John Uplands region (Schlawin & Cutko, 2014). WMD 8 and WMD 2 are comprised of similar landscapes and are in regions composed mainly of Acadian low elevation spruce-fir-hardwood forests (16% and 26% respectively) and Laurentian-Acadian northern hardwood forests (27% and 26% respectively); over 30% of the land in each region is considered conserved land (Schlawin & Cutko, 2014). We analyzed WMD 8 and WMD 2 jointly in this study to capture a wider range of variability in winter weather conditions across regions in Maine with high moose densities and similar forest harvesting dynamics.
2.3 Methods

2.3.1 Moose Locations

We acquired the moose location data for this study from a subset of GPS-collared moose (Vertex Globalstar, Vectronic) that were part of a larger demographic study on moose survival in Maine, conducted by the MDIFW (Elliot, 2019; Maine Department of Inland Fisheries and Wildlife, n.d.-a). GPS locations were collected twice daily, at 5:00am and 5:00pm EST time, and locations were downloaded daily via satellite using GPS Plus X software (Vectronic Aerospace GmbH). For this study, GPS location data was collected for a total of 96 individual adult female moose. A total of 61 individuals were collared in WMD 8, and 35 individuals were collared in WMD 2. Some individuals were collared for multiple winters during the study period. These data span six years starting in 2013 and ending in 2019. We utilized GPS points taken during the winter season, defined as December 15-March 15 based on when resources are the most limited, temperatures are coldest, and snow cover is the most prevalent (Dussalt, 2005; Schwartz & Renecker, 1998), to calculate winter home ranges.
2.3.2 Home Range Generation

To characterize winter habitat we analyzed second-order resource selection, defined as individual home-range selection within a species geographical range (Johnson, 1980). Individuals with less than 30 points for a winter season, December 15-March 15 for a given year, were not included in the study, as data was too sparse to approximate an accurate home range (Seaman et al., 1999), and likely indicated that the individual died or the GPS collar malfunctioned. Kernel Density Estimation (KDE) was used to calculate utilization distribution (UD) (Worton, 1989) for individual moose home ranges using the package adehabitatHR (Calenge, 2006) in R (R Core Team, 2021). The reference bandwidth for \( h (h_{ref}) \) was used to determine smoothing (Blundell et al., 2001; Hemson et al., 2005), and calculate 95% UD home range polygons for each individual. Landscape variables were quantified within each 95% UD polygon to calculate individual habitat use for each adult female for each winter season. We characterized availability of landscape features using a case-control design by buffering an individual’s winter home range by the median annual home range size for the study area to match available location scale to the scale at which moose were selecting home-range habitat (Boyce, 2006). This allowed us to compare the composition of an individual’s winter home range to what might be available to an individual given its annual movements. To calculate the median home range size, annual home ranges were computed at 95% UD for each individual using KDE where GPS points existed for at least six months out of a single year in order to establish annual ranges that were reflective of use through multiple seasons. We then calculated the median area of annual home ranges for all these individuals using ArcGIS Pro (Version 2.6.3) in order to identify annual moose movement on the landscape. This median annual movement was used as the buffer distance for all individual winter home ranges. This allowed us to characterize available habitat corresponding to each home range and determine habitat selection by comparing use to availability for each individual.

2.3.3 Environmental Variables

We included landscape variables such as elevation, slope, and land cover to assess determinants of moose habitat selection. Elevation was obtained from Digital Elevation Models (DEM's) and
calculated as an average for each home range polygon. Slope was also calculated from the DEM's using ArcGIS and averaged within each home range. Landscape composition classification was determined using the 2016 National Land Cover Database (NLCD) Land Cover product (NLCD, 2016). Land class variables that composed less than 5% of the available landscape were excluded from the analysis due to low biological significance and limited presence on the landscape. We identified five land classes to include in our analysis: (1) mixed forest, (2) evergreen forest, (3) deciduous forest, (4) regenerating (shrub forest, herbaceous forest, shrub scrub, herbaceous), and (5) wetlands (woody wetlands and emergent herbaceous wetlands). The NLCD product used in this study included spectrally transitioning shrub (shrub forest) and spectrally transitioning grass (herbaceous forest) land classes, which are considered regenerating forest habitats (Homer et al., 2020). Woody wetlands and emergent herbaceous wetlands were combined into a single wetlands class. Spectrally transitioning shrub, spectrally transitioning grass, herbaceous, and shrub scrub were all combined into a regenerating land class.

Mixed, evergreen, and deciduous forest land classes encompass all mature forested landscapes. The mixed forest land class includes both evergreen and deciduous tree species, and therefore can provide opportunity for both cover and forage. Evergreen forests in this study area are composed mainly of spruce and fir species. Hardwood trees are present in this region in both the mixed and deciduous land classes. Evergreen land classes provide cover resources for moose during the winter, while deciduous land classes provide forage resources. The regenerating land class includes young trees and shrubs that provide forage for moose and is considered a more open landscape.

We calculated winter weather metrics from NOAA Global Historical Climate Network Daily Summaries (NOAA, n.d.) and the Maine Cooperative Snow Survey (MDACF, n.d.) to be included in the model selection process to assess if weather influenced habitat use. We calculated mean values of each weather variable for each winter season. The weather variables included: (1) minimum temperature, (2) maximum temperature, (3) precipitation, (4) snowfall, (5) average snow depth, and (6) average snow density. Snow depth and density were obtained from the Maine Cooperative Snow Survey (MDACF,
n.d.). We utilized these weather variables to explore how factors affecting winter severity, such as winter temperatures and snow depth influence moose use of the landscape.

2.3.4 Statistical Analysis

Resource Selection was estimated using generalized linear mixed models (GLMM) in R. Land classes were included in the model development if they comprised greater than 5% of the total available landscape. Slope and elevation were also included in the model selection process and the resulting beta values were assessed for significance. All landscape variables were included as fixed effects, with individual and WMD included as random effects (Manly et al., 2002; Hebblewhite & Merrill, 2008). We assessed the influence of weather conditions of habitat selection by examining interactions between weather variables and land classes. Collinearity of variables was assessed using Pearson correlation coefficients. Any variables with correlations greater than 0.600 were not included in the same model; collinearity was dealt with by removing highly correlated variables from the same model based on ecological relevance (Graham, 2003). Variables that were removed from a model due to high correlation with another variable that remained in the model were subsequently tested in the same model in place of the retained variable in order to see which was better supported.

Model fit was assessed using Akaike’s Information Criterion (AIC), which compares each model's complexity to the variance explained by the model (Burnham & Anderson, 2002). AIC allowed us to compare model performance across our models, and determine which model best explained the data while also being the simplest. The model with the lowest AIC was selected as the model with the best fit to our data. Beta estimates were used to compare the land class variable effect sizes and identify significant effects: standard error confidence intervals that did not overlap zero suggested a significant effect size. Standardized beta estimates were used to test our hypotheses regarding the influence of winter weather conditions on habitat selection.

First, we identified a base model that contained the land class variables supported by our model selection process. Then we included the weather variables as interaction terms with the land class variables in this base model to assess the influence of winter weather on selection. Interactions between
each weather variable and each landscape variable in the base model were tested one at a time. The resulting model fits were compared to the base model. Interactions that produced lower AIC values were retained to identify our final model.

2.4 Results

A total of 222 annual winter home ranges were calculated for female-adult moose during our study period. The average winter home range size, excluding two major outliers, was 18.69 km$^2$ with a standard deviation of 22.86 km$^2$. The available habitat was composed mainly of forest landscapes (85.7%): mixed forest comprised 30% of the available habitat, with evergreen and deciduous making up 20% and 19% respectively. Regenerating forest comprised 17% of the landscape, with wetlands (8.9%) and other open land classes (5.4%) comprising the remainder (Table 2.1).

Table 2.1. Composition of available landscape.

<table>
<thead>
<tr>
<th>Land class</th>
<th>Percent of landscape</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mixed Forest</td>
<td>30.05</td>
</tr>
<tr>
<td>Evergreen Forest</td>
<td>20.29</td>
</tr>
<tr>
<td>Deciduous Forest</td>
<td>18.66</td>
</tr>
<tr>
<td>Regenerating</td>
<td>16.65</td>
</tr>
<tr>
<td>Wetlands</td>
<td>8.93</td>
</tr>
<tr>
<td>Open Water$^1$</td>
<td>3.00</td>
</tr>
<tr>
<td>Developed$^1$</td>
<td>2.08</td>
</tr>
<tr>
<td>Barren Land$^1$</td>
<td>0.30</td>
</tr>
<tr>
<td>Crops/Pasture$^1$</td>
<td>0.01</td>
</tr>
</tbody>
</table>

$^1$ Land class was excluded from analysis since it comprised less than 5% of the landscape.

Late winter sees the highest annual energy expenditure by moose (Regelin et al., 1985; Schwartz et al., 1991); warmer temperatures and lower snow depths reduce energy expenditure (Timmerman & McNicol, 1988). Over the course of the study there was considerable variation in average snow depth, snow density, and average maximum temperature (Figure 2.2). Snow depth ranged between 13 in and 30 in, with the highest average snow depth in 2019 and lowest in 2013. The values for snow density (calculated as water content (in)/ snow depth (in)) ranged between 0.18-0.35 with the highest occurring in
2013 and lowest in 2018. The winter with the highest maximum temperature was 2016, which saw an average of 27 degrees F. The year with the lowest average maximum temperature, 17 degrees F, was 2014. The year 2016 was mild compared to others in the study period with high temperatures and low snow depths in both WMD's (Figure 2.2). WMD 8 saw slightly higher maximum winter temperatures and slightly lower snow depths on average over the past 20 years compared to WMD 2 (Figure 2.2).

Figure 2.2. Average winter snow depth (in) and average winter maximum temperature (°F) from 2000-2019, including study period from 2013-2019, for WMD 2 and 8. Mean average snow depth and mean average maximum temperature for 2000-2019 are presented as the combined mean of both WMD's.

As expected, many of the climate variables were correlated (Table 2.2) with high correlation (>0.60) between snow depth and snowfall (0.75), snowfall and precipitation (0.78), and minimum temperature and maximum temperature (0.89). These highly correlated variables were not included in the same model with their correlated counterparts since snow depth, snowfall, and precipitation were tested separately in the base model. Given that maximum temperature and minimum temperature were highly correlated, we only considered maximum temperature in our model set.
Table 2.2. Matrix of correlation.

<table>
<thead>
<tr>
<th>Variables</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
<th>(8)</th>
<th>(9)</th>
<th>(10)</th>
<th>(11)</th>
<th>(12)</th>
<th>(13)</th>
<th>(14)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Precipitation</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(2) Snowfall</td>
<td>0.78</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(3) Max temperature</td>
<td>0.15</td>
<td>-0.07</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(4) Min temperature</td>
<td>0.19</td>
<td>-0.20</td>
<td>0.89</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(5) Snow depth</td>
<td>0.47</td>
<td>0.75</td>
<td>-0.23</td>
<td>-0.45</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(6) Snow density</td>
<td>-0.04</td>
<td>0.12</td>
<td>-0.11</td>
<td>0.06</td>
<td>0.17</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(7) Slope</td>
<td>0.01</td>
<td>-0.06</td>
<td>-0.00</td>
<td>0.07</td>
<td>-0.08</td>
<td>0.01</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(8) Elevation</td>
<td>-0.25</td>
<td>-0.13</td>
<td>0.07</td>
<td>-0.03</td>
<td>-0.10</td>
<td>0.06</td>
<td>0.54</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(9) Deciduous forest</td>
<td>-0.08</td>
<td>-0.10</td>
<td>0.07</td>
<td>0.08</td>
<td>-0.10</td>
<td>0.04</td>
<td>0.61</td>
<td>0.57</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(10) Evergreen forest</td>
<td>-0.04</td>
<td>0.04</td>
<td>0.02</td>
<td>-0.01</td>
<td>0.00</td>
<td>0.05</td>
<td>-0.36</td>
<td>-0.21</td>
<td>-0.57</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(11) Mixed forest</td>
<td>0.25</td>
<td>0.10</td>
<td>-0.08</td>
<td>-0.00</td>
<td>0.09</td>
<td>-0.13</td>
<td>0.03</td>
<td>-0.22</td>
<td>-0.21</td>
<td>-0.36</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(12) Developed</td>
<td>-0.01</td>
<td>0.13</td>
<td>0.05</td>
<td>-0.03</td>
<td>0.11</td>
<td>0.13</td>
<td>-0.19</td>
<td>0.01</td>
<td>-0.16</td>
<td>0.06</td>
<td>-0.22</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(13) Regenerating forest</td>
<td>-0.08</td>
<td>-0.10</td>
<td>-0.01</td>
<td>-0.02</td>
<td>-0.04</td>
<td>-0.08</td>
<td>0.08</td>
<td>0.04</td>
<td>-0.13</td>
<td>-0.24</td>
<td>-0.10</td>
<td>0.01</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>(14) Wetlands</td>
<td>-0.02</td>
<td>0.05</td>
<td>-0.06</td>
<td>-0.10</td>
<td>0.05</td>
<td>0.09</td>
<td>-0.57</td>
<td>-0.40</td>
<td>-0.39</td>
<td>0.18</td>
<td>-0.29</td>
<td>0.24</td>
<td>-0.16</td>
<td>1.00</td>
</tr>
</tbody>
</table>
2.4.1 Resource Selection

The best model, as identified by AIC rank, contained variables for deciduous forest, evergreen forest, mixed forest, regenerating forest, and wetlands, along with an interaction between regeneration and snow density (Table 2.3). WMD and individual ID were included as random effects in all models. The base model contained all biologically relevant landscape variables: deciduous forest, evergreen forest, mixed forest, regenerating forest, and wetlands (AIC = 579.6, df = 8). Models including elevation and slope separately saw higher AIC values (581.6, df = 9) compared to the base model (Table 2.3).

Table 2.3. GLMM model results.

<table>
<thead>
<tr>
<th>Model</th>
<th>df</th>
<th>AIC</th>
<th>ΔAIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deciduous_Forest + Evergreen_Forest + Mixed_Forest + Regen*Snow_Density + Wetlands + (1</td>
<td>WMD) + (1</td>
<td>ID)</td>
<td>10</td>
</tr>
<tr>
<td>Deciduous_Forest + Evergreen_Forest + Mixed_Forest + Regen + Wetlands + (1</td>
<td>WMD) + (1</td>
<td>ID)</td>
<td>8</td>
</tr>
<tr>
<td>Elev + Deciduous_Forest + Evergreen_Forest + Mixed_Forest + Regen + Wetlands + (1</td>
<td>WMD) + (1</td>
<td>ID)</td>
<td>9</td>
</tr>
<tr>
<td>Slope + Deciduous_Forest + Evergreen_Forest + Mixed_Forest + Regen + Wetlands + (1</td>
<td>WMD) + (1</td>
<td>ID)</td>
<td>9</td>
</tr>
</tbody>
</table>

Note: df=degrees of freedom, AIC=Akaike Information Criteria value, ΔAIC=difference between model AIC and lowest model AIC.

The inclusion of interactions between weather variables and landscape variables found a significant interaction between regenerating forest and snow density (p=0.038) while all other interaction terms tested against the base model were not significant (Table 2.4). Including the interaction between regenerating forest and snow density in the base model saw a 0.4 improvement in AIC (Table 2.4).
Table 2.4. Model results from assessment of interaction between land class variables and yearly winter severity metrics.

<table>
<thead>
<tr>
<th>Model variable</th>
<th>Interaction term variable</th>
<th>Estimate</th>
<th>df</th>
<th>AIC</th>
<th>ΔAIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regenerating</td>
<td>Snow Density</td>
<td>-1.43036*</td>
<td>10</td>
<td>579.2</td>
<td>-0.4</td>
</tr>
<tr>
<td></td>
<td>Snow Depth</td>
<td>NA</td>
<td>10</td>
<td>583.5</td>
<td>3.9</td>
</tr>
<tr>
<td></td>
<td>Min Temp</td>
<td>NA</td>
<td>10</td>
<td>582.7</td>
<td>3.1</td>
</tr>
<tr>
<td>Deciduous Forest</td>
<td>Snow Density</td>
<td>0.12391</td>
<td>10</td>
<td>583.5</td>
<td>3.9</td>
</tr>
<tr>
<td></td>
<td>Snow Depth</td>
<td>NA</td>
<td>10</td>
<td>582.6</td>
<td>3.0</td>
</tr>
<tr>
<td></td>
<td>Min Temp</td>
<td>NA</td>
<td>10</td>
<td>583.2</td>
<td>3.6</td>
</tr>
<tr>
<td>Evergreen Forest</td>
<td>Snow Density</td>
<td>-0.02151</td>
<td>10</td>
<td>583.6</td>
<td>4.0</td>
</tr>
<tr>
<td></td>
<td>Snow Depth</td>
<td>NA</td>
<td>10</td>
<td>583.5</td>
<td>3.9</td>
</tr>
<tr>
<td></td>
<td>Min Temp</td>
<td>NA</td>
<td>10</td>
<td>583.5</td>
<td>3.9</td>
</tr>
<tr>
<td>Mixed Forest</td>
<td>Snow Density</td>
<td>0.51883</td>
<td>10</td>
<td>582.5</td>
<td>2.9</td>
</tr>
<tr>
<td></td>
<td>Snow Depth</td>
<td>NA</td>
<td>10</td>
<td>583.2</td>
<td>3.6</td>
</tr>
<tr>
<td></td>
<td>Min Temp</td>
<td>NA</td>
<td>10</td>
<td>583.5</td>
<td>3.9</td>
</tr>
</tbody>
</table>

Note: df=degrees of freedom, AIC=Akaike Information Criteria value, ΔAIC=difference between model AIC and base model AIC. *p<0.1; **p<0.05; ***p<0.01

The inclusion of the interaction between regenerating forest and snow density in the base model saw a lower AIC (579.2, df = 10) than that of the base model (579.6, df = 8). Slope and elevation were not included in the base model or final model since their inclusion was not supported by model selection. The best model consisted of the base model plus the interaction between regenerating forest and snow density.

We did not find support for our hypothesized interaction between evergreen forest use and snow density or snow depth as evidenced by nonsignificant interaction term results (Table 2.4), which indicates that winter severity did not increase use of softwood stands.
All land class variables included in the final model were significant. The interaction term between regeneration and snow density was significant, while snow density as a single term in the model was borderline significant (p = 0.051). There was a positive relationship between the forest land classes and use with the model estimates being 0.205 for deciduous forests, 0.236 for evergreen forests, and 0.239 for mixed forests (Table 2.5). The regenerating land class had a positive relationship with use (β = 0.517, SE = 0.16). There was also a positive relationship between wetlands and use (β = 0.221, SE = 0.05). There was a weak negative effect between the regeneration and snow density interaction term (β = -1.430, SE = 0.69) (Table 2.5).

Table 2.5. Model beta estimates and standard errors.

<table>
<thead>
<tr>
<th>Model variable</th>
<th>Estimate (SE)</th>
<th>95% ci</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deciduous forest</td>
<td>0.205*** (0.038)</td>
<td>0.130, 0.279</td>
</tr>
<tr>
<td>Evergreen forest</td>
<td>0.236*** (0.039)</td>
<td>0.160, 0.312</td>
</tr>
<tr>
<td>Mixed forest</td>
<td>0.239*** (0.040)</td>
<td>0.161, 0.317</td>
</tr>
<tr>
<td>Regenerating forest</td>
<td>0.517*** (0.160)</td>
<td>0.203, 0.832</td>
</tr>
<tr>
<td>Snow density</td>
<td>24.791* (12.69)</td>
<td>-0.070, 49.653</td>
</tr>
<tr>
<td>Wetlands</td>
<td>0.221*** (0.044)</td>
<td>0.134, 0.307</td>
</tr>
<tr>
<td>Regenerating forest:Snow density</td>
<td>-1.430** (0.691)</td>
<td>-2.785, -0.076</td>
</tr>
</tbody>
</table>

Note: *p<0.1; **p<0.05; ***p<0.01

Standardized model estimates were 11.69 for evergreen forest, 10.19 for deciduous forest, and 9.58 for mixed forest which all had the strongest effects (Figure 2.3). Regeneration and wetland land classes saw slightly lower standardized estimates at 3.87 and 3.55 respectively, while snow density saw no effect and the interaction between regeneration and snow density saw a slight negative effect with a standardized estimate of 0.80 (Figure 2.3).
Deciduous forest had a slightly higher RSF value (Figure 2.4) as compared to evergreen and mixed forest suggesting that deciduous forest was used at a higher rate than the other two forest land classes. Low snow density saw higher use of the regenerating forest land class when it composed more than 20% of the available landscape (Figure 2.4).
Figure 2.4. Resource Selection Functions (RSF), relative predictive probability of use for A) deciduous, evergreen, and mixed forest; and B) regenerating forest as a function of snow density.

2.5 Discussion

Moose selected forested areas during winter and showed similar preference for deciduous, evergreen, and mixed forests. We did not identify a strong preference for any particular forest type since deciduous, evergreen, and mixed forest were selected relatively equally by moose monitored in this study. Mixed forest comprises a greater proportion of available home range habitat and can provide both cover and forage in the winter, which suggests that moose do not need to use solely evergreen or deciduous land.
classes to meet their needs in the winter. These findings are in line with prior research, which has established that moose select for largely forested habitat at the home range scale (Wattles & Destefano, 2013), with a preference for red maple which can occur in both deciduous and mixed forest habitats in Maine (DeGraaf et al., 1992). Research has also established that moose tend to favor young regeneration for forage, with optimal habitat consisting of 4-16 year old forest openings (Healy et al. 2018).

We did not identify a difference in selection of forest types based on winter conditions. This suggests that all mature forest classes provide adequate food and cover resources for moose in the winter regardless of weather conditions. Our hypothesis that moose would select for evergreen habitats more in winters with higher amounts of snow was not supported by our results. This suggests that moose are not necessarily using evergreen forests at the home range scale to minimize energy expenditure in more severe winters. Prior research on moose habitat in New Hampshire also found no impacts of snow depth on access to forage, as well as no real changes in habitat selection based on season (Scarpitti et al., 2005). This suggests that moose habitat in New England is widely distributed on the landscape and that moose access to forage and cover resources are not especially limited by deep snow. Other research has found an increase in browsing on pine in winter, along with utilization of older forests for the canopy cover and lower snow accumulation they provide (Bjørneraas et al., 2011). It is possible that the amount of snow accumulation in the years during our study period was not enough for moose to seek out home ranges with higher cover availability in the form of evergreen forests. It is also possible that Maine's complex forest matrix provides enough older forests and canopy cover in mixed and deciduous forests, alongside evergreen forests, so that moose can find adequate cover without selecting specifically for evergreen forest land classes at the home range scale. The interaction between moose and habitat is complex, and there may be other nuanced factors influencing moose use of the landscape including microhabitats within this forested landscape, forest age, and forest structure.

Open habitat, consisting of wetlands and regenerating forests, were also utilized alongside forested habitat during the winter. Regenerating forests were used at a slightly lower rate than the other forested land classes, possibly due to the ability of more mature forests to provide both cover and forage
resources during winter. Maine’s large swaths of forest and variety of different forest regeneration patterns (Butler, 2018; Wiersma, 2009) provide a sizable amount of forested habitat for moose to utilize.

While temperature has not been shown to change habitat selection in the winter (Van Beest et al., 2012), weather related to snow conditions is likely influencing moose use of forage and cover resources on the landscape when snow is especially deep (>90cm) (Ballenberghe & Ballard, 1998; Courtois et al., 2002; Peek, 1998). Our results indicate that selection for regenerating forests is stronger in years with less snow. This suggests that in winters with lower snow densities, moose may use regenerating forests more. This supports the hypothesis that moose select habitat to maximize forage resources in the winter. Our results suggest that moose are better able to use regenerating forage resources in winters with lower snow densities. These findings indicate that forest harvesting that results in patchy forest regeneration could provide more forage resources for moose in winters with lower snow densities. Taking this into account could be important for forest managers since higher moose browsing on regenerating areas has the potential to alter regeneration patterns (Andreozzi et al., 2014; Bergeron et al., 2011; Pastor & Naiman, 1992). This increased use of regenerating forest during milder winters has implications for understanding how moose landscape use may change as climate conditions in Maine change.

Winters with lower snow density could see moose utilizing open regenerating forest habitat more. Snow cover conditions, namely snow depth and duration of snow cover, can influence how moose interact with the landscape in the winter (Christenson et al., 2014). Low snow conditions, which are expected to become more frequent in Maine as a result of climate change (Fernandez et al., 2020), have been indicated as leading to changes in moose browsing preferences (Christenson et al., 2014). Moose home ranges can be influenced by snow depth (Poole & Stuart-Smith, 2006), and based on our results it is likely that snow density also plays a role in moose landscape use.

The potential increase in use of regenerating habitat in milder winters implications for forest regeneration in Maine. If milder winters facilitate more year round use in these areas by moose, there is potential for moose impacts on regenerating forests to increase. Increased browsing on regenerating landscapes could result in changes in forest succession patterns due to selective browsing (Andreozzi et
Moose browsing activity can alter species composition, abundance, and diversity of both tree and shrub species, especially when deer browsing is also present (Faison et al., 2016). Milder winters in Maine, especially those with little snow accumulation, could see more moose browsing occurring in regenerating landscapes, which has implications for increased moose impact on those habitats. More use of these open areas by moose would also increase browse availability and ease of access to food resources for moose.

Changing winter conditions in Maine are likely to alter how moose are utilizing habitat at the home range level. Along with different landscape use, milder winters could facilitate increased parasite and disease stressors in Moose. Winter ticks pose threats to moose health, and warmer winters have been cited as facilitating winter tick survival (Samuel, 2007), and leading to heavy infestations of winter ticks on moose (Bergeron et al., 2013). This has implications for a decline in overall health and may lead to anemia, skin irritation, hair loss, and in extreme cases death (Jones et al., 2019; Musante et al., 2007; Samuel, 2007). Interactions between moose and white-tailed deer, which can increase winter tick loads and facilitate an increased transmission of diseases between populations, are also a concern associated with shorter and milder winters. High deer densities, along with less snow on the ground in winter, has also been known to increase the availability of hosts and the period of transmission of meningeal worm from deer to moose (Lanester, 2010).

While milder winters have implications for increasing disease and parasite stressors in moose, the potential increased utilization of regenerating forage habitat in years with less snow accumulation indicates that moose could have more resources and could expend less energy foraging. This could provide moose with an increased ability to combat the negative effects of diseases and parasites. While warmer winters and regenerating habitat use could facilitate increased winter tick infestation (Healy et al., 2018), they could also afford opportunities for moose to utilize more of the landscape and reduce energy expenditure related to cold temperatures and high snow conditions. This indicates that milder winters could see either increased winter tick infestations and declines in moose population health, or increased moose survival rates and healthier moose populations, which highlights an area for future research.
work is being done to understand winter tick ecology and the impact of winter tick infestations on moose (Healy et al., 2018; Pekins, 2020), and to better understand how warmer winters facilitate winter tick survival and infestation, as well as how warmer winter could impact moose energetics and resource use. Understanding these dynamics will be essential in addressing the complex relationships between moose, parasitism, and climate change.

During our study period, 2013 to 2019, there were winters with a range of different weather conditions. While some years saw quite cold average minimum temperatures, -5.06 degrees in 2018, and high average snow depths, 28.12 inches in 2019, no one year during our study period could be considered the most severe. The mildest winter during our study period occurred in 2016. While our results support a difference in selection based on snow density, a longer study period that contains distinctly severe or mild winters could benefit the analysis of moose response during abnormal winter conditions.

More work is required to understand how snow density, and other winter severity metrics, influence daily landscape use by moose, as well as any delayed responses to winter conditions that impact moose habitat selection. While it is clear that moose use all forest types, as well as regenerating habitat, data with a more fine-scale forest structure resolution would provide more insight into winter selection preferences. More details regarding forest species composition and stand age could help fine-tune our understanding of how moose are using Maine's winter landscape, including how moose forage preference for red maple influences habitat selection at different scales (DeGraaf et al., 1992). This would also elaborate on our understanding of how moose distinguish cover versus forage resources. These findings can contribute to moose management by providing information on what landscapes moose are using in the winter, implications for moose distribution in the state and related hunting permit locations, and considerations for management and planning to address potential impacts of climate change on moose population health. The relationship between snow density and moose landscape use established in this study highlights the importance of understanding how changes in winter severity over time will impact moose habitat selection preferences.
CHAPTER 3
OUTDOOR RECREATIONIST PERCEPTIONS OF MOOSE IN MAINE AND POTENTIAL SUPPORT OF MOOSE MANAGEMENT STRATEGIES

3. 1 Introduction

Moose (*Alces alces americana* Linnaeus, 1758) are an iconic species in the state of Maine; there is a strong relationship between people and moose in the state. Moose are valued for many reasons, some of which include cultural/spiritual value, sustenance, ecological value, and recreational hunting (Timmermann & Rodgers, 2005). Active management of the moose population in Maine plays an important role in moose population health, while guiding interactions between people and moose (Ericsson, 2003). In Maine, moose management is conducted by the Maine Department of Inland Fisheries and Wildlife (MDIFW) and the Wabanaki tribes. Wabanaki tribes have jurisdiction over harvesting wildlife on their lands, and moose hunting is a large part of Wabanaki culture and traditions (DiMatteo-LePape, 2019; Elliott, 2019). The primary mechanism of moose management by the MDIFW is moose hunting (Brown et al., 2000; Maine Dept. of Inland Fisheries and Wildlife [MDIFW], 2017; Maine Dept. of Inland Fisheries and Wildlife [MDIFW], n.d.-a). Designating annual moose hunting permit amounts, and determining where in the state hunters are allowed to harvest moose, maintains a healthy density and distribution of moose, while providing hunting opportunities to in-state and out-of-state recreationists (Boyce, Baxter, & Possingham, 2012). A healthy moose population is important in Maine since many people rely on moose for income, sustenance, and cultural traditions (Timmermann & Rodgers, 2005).

Outdoor recreation is very popular in Maine, with hunting being an important social, cultural, and economic activity (Auger, 2006; Southwick Associates, 2014; 2014; LaBarbera, 2002; Timmermann & Rodgers, 2005). Moose hunting sees high levels of participation, with over 65,000 people entering the annual moose hunting permit lottery hoping to win one of approximately 3,000 permits annually (Maine Dept. of Inland Fisheries and Wildlife [MDIFW], n.d.-b). A small amount of these annual permits, 8%,
are allocated to out-of-state moose hunters, which attracts hunters from all over the country to Maine (Auger, 2006; MDIFW, n.d.-b). There are people in Maine who rely on moose hunting to support their businesses and income every year, including moose hunting guides and hunting lodge owners (Timmermann & Rodgers, 2005). In 2013, the total economic contribution of moose hunting (including employment, labor income, and value added to the state) was over $20,800,000 in Maine, with a total annual expenditure by hunters of $15,793,765 (Southwick Associates, 2014).

While Maine's moose population is the largest in the lower 48 United States (MDIFW, n.d.-a), it still faces challenges resulting from climate change, mainly in the form of disease and parasitism (Fernandez et al., 2020; Malmsten et al., 2018; Murray et al., 2006). Changing forest conditions and compositions resulting from climate change also have the potential to change moose population dynamics, and influence their distribution across the landscape (Rodenhouse et al. 2009; Rustad et al., 2012; Weiskopf, Ledee, & Thompson, 2019). Winter tick (*Dermacentor albipictus* Packard, 1869) and meningeal worm (*Parelaphostrongylus tenuis* Boev & Schultz, 1950) are two parasites present in Maine moose populations (Jones et al., 2019; Lankester, 2010; Samuel, 2007). Winter tick parasitism has resulted in high tick loads on individual moose: thousands of ticks can feed on a single moose from when they find a moose host in the fall until they drop off in the spring (Ellingwood et al., 2020; MDIFW, n.d.-a; Samuel, 2007). Winter ticks have negatively impacted the moose population in recent years (Jones et al., 2019; Samuel, 2007): high winter tick infestation can lead to anemia and death, and is the leading cause of current moose population declines (Ellingwood et al., 2020; Elliott 2019; Jones et al., 2019; Musante et al., 2010). Moose calves are especially susceptible to the negative impacts of heavy winter tick infestation (Jones et al., 2019); Maine has seen an increase in moose calf mortality (>50%) as a consequence (MDIFW, n.d.-a; Musante et al., 2010; Jones et al., 2019). Warmer winters facilitate winter tick survival and Maine has seen an increase in average annual temperatures of 3.2 degrees Fahrenheit in the last 124 years (Fernandez et al., 2020; Jones et al., 2019). Warmer temperatures resulting from climate change, as well as increased moose density in parts of the state, have exacerbated the interaction between moose and winter ticks (Ellingwood et al., 2020; Samuel, 2007).
This study was informed by preliminary qualitative results gathered through a single case study on risk perceptions of moose-winter tick interactions in Maine conducted in 2018 and 2019 (DiMatteo-LePape, 2019; Elliott 2019). This qualitative exploration utilized multiple data generation techniques including a review of archival evidence (i.e., scientific literature, newspaper articles, cultural stories), semi-structured interviews (Miles, Huberman, & Saldana, 2020), open-ended responses from a questionnaire of Penobscot Nation citizens (Elliott, 2019), and the researcher’s reflective journal. Key results from this study suggest that stakeholders (i.e., hunters, outfitters, wildlife managers, Wabanaki citizens) are concerned about moose health, including fears that a decline in moose health and moose populations could reduce moose hunting and viewing opportunities. Stakeholders expressed that a reduced ability to hunt and view moose could impact Maine’s culture of hunting and outdoor recreation, as well as tourism. Both tourism and hunting contribute to Maine’s economy, and there were concerns that a reduction in hunting permits and moose viewing opportunities would negatively impact outfitting businesses and Maine’s economy as a whole (DiMatteo-LePape, 2019). Wabanaki citizens specifically expressed concerns that a decrease in healthy moose could impact their cultural traditions and sustenance hunting practices (Elliott, 2019; Prins & McBride, 2007).

Reducing moose density in parts of the state has been proposed as a management strategy to combat increasing calf mortality and declines in moose health driven by the winter tick infestation rates (MDIFW, n.d.-b). This strategy is based on the hypothesis that lowering moose density would reduce winter tick transmission between individuals and populations (Ellingwood et al., 2020). This new management strategy would involve increasing moose hunting permit amounts in some areas in Maine where moose densities are high and winter tick infestation is prevalent (MDIFW, n.d.-a; MDIFW, n.d.-b), and hence is likely to have both strong supporters and strong opponents.

This study sought to understand how different groups of outdoor recreationists in the state (i.e., moose hunters, non-moose hunters, and non-hunters) perceive the status of the moose population in Maine, risks to moose health such as winter ticks, the role of moose hunting as a management strategy to reduce moose densities and winter tick infestation, and different moose management strategies. We
sought to (1) explore beliefs about the current moose population and moose hunting in Maine, (2) assess outdoor recreationist attitudes towards and intention to engage in behaviors that could potentially benefit moose population health in Maine, (3) measure outdoor recreationist moose health risk perceptions, and (4) explore if beliefs, attitudes, potential support of management, and parasite risk perceptions differ between outdoor recreation groups.

3.2 Significance

Understanding how stakeholders perceive the status of the current moose population, threats to moose, and moose hunting has implications for public support of management strategies and policies in the state. Management and policy decisions can be influenced by stakeholder perceptions, especially through politics and lobbying since most wildlife management agencies are established by legislature and considered in the government sphere (Lute & Gore, 2014). Public acceptance is key to successful wildlife management (Zinn et al., 1998). Understanding how different groups perceive moose hunting and moose management will aid in communication strategies and will contribute to a better understanding of the human-moose relationship in Maine. Effective communication and outreach that targets specific groups can garner support and acceptance for management strategies given that different groups have unique values, needs, knowledge, and attitudes (Bourne, 2016). Persuasive communication has been shown to be a valuable tool in bolstering hunting to achieve wildlife-disease management objectives when wildlife populations are perceived as being too small by potential hunters (Triezenberg et al., 2014). Persuasive communication can be used to promote changes in wildlife attitudes, perceived norms, and behavioral intentions to support management strategies (Triezenberg et al., 2014).

Gaining an understanding of how moose hunters, non-moose hunters, and non-hunter Maine recreationists perceive the current moose population in Maine, as well as their risk perceptions and attitudes toward moose hunting as a management strategy, is important since hunters play a key role in helping maintain a healthy moose population (Boyce, Baxter, & Possingham, 2012). Motivations for hunting and hunting success can also influence acceptance of moose management strategies (Brinkman, 2018). Motivations to hunt can include different aspects of achievement, affiliation, and appreciation (Decker &
Connelly, 1989); wildlife management has also been found as a motivation for hunting and trapping (Bhandari et al., 2006; Dorendorf, Fix, & Prugh, 2016). A study on the acceptance of antlerless moose hunts found that the majority (99%) of respondents were strongly motivated to hunt moose for meat, while only 85% approved of antlerless hunts (Brinkman, 2018), which suggests that the relationship between support of wildlife management and engagement in activities that support management is complex. Understanding how different groups view hunting as a management strategy and support increased hunting, as well as their likelihood to hunt moose in the future, can increase our knowledge of the human-dimensions of moose hunting in Maine.

While moose hunters are actively involved in the management of the species through hunting, non-moose hunters contribute to additional wildlife management that impacts moose including white-tailed deer hunting. Non-hunter Maine recreationists are part of the human-moose system in Maine who may value moose differently than hunters and can still play a role in actively supporting or protesting moose management strategies. Knowledge surrounding stakeholder beliefs, attitudes, and perceptions can support wildlife management by helping managers design management goals and objectives that take into account the values people have for moose (Van Eeden et al., 2017), and by contributing to the development of communication and outreach aimed at bolstering support and acceptance of management actions (Lute & Gore, 2014; Zinn et al., 1998).

Understanding social perceptions of the MDIFW can also help the agency maintain its social license. Social license is the community support and consent for a business, or agency, to operate (Gunningham, Kagan, & Thornton, 2004). In order to maintain and or increase support of the public, wildlife management agencies need to understand the values that people have towards wildlife and uphold expectations that people have about management (Hampton & Teh-White, 2019). Maintaining social license can support management by bolstering support for the agency regardless of specific management strategies (Gunningham, Kagan, & Thornton, 2004).

Preliminary data gathered on values towards moose and perceptions of moose-winter tick interactions in Maine suggests that stakeholders, namely hunters, moose hunting outfitters, and Wabanaki...
citizens, see moose hunting as part of Maine culture, tourism, and a form of sustenance and cultural significance for Wabanaki peoples in Maine (DiMatteo-LePape, 2019; Elliott, 2019). Wabanaki cultures have many ties to moose including creation stories centered around moose (PINAHCP, 2011), rites of passage that involve moose hunting (DiMatteo-LePape, 2019), and traditional crafts reliant on materials from moose (Kent, 2014). Further, changes in the ability to hunt moose can impact Maine hunting traditions, economic benefits from tourism, and cultural practices (Timmermann & Rodgers, 2005). A greater understanding of stakeholder moose health risk perceptions, wildlife values, and attitudes towards wildlife management strategies can help inform communication and outreach strategies, and provide a more comprehensive understanding of outdoor recreationist potential support towards specific moose management strategies.

3.3 Conceptual Framework

This study was directed by a broad conceptual framework to measure beliefs and risk perceptions of moose in Maine, as well as attitudes and behaviors related to the support of moose management strategies. Our research utilized scales derived from three main sets of theories: Cognitive Hierarchy Model of Human Behavior, the Theory of Planned Behavior, and risk perception theory.

3.3.1 Cognitive Hierarchy Model of Human Behavior

Values and beliefs form the foundations of a person's attitudes towards wildlife, and in turn their behavior towards supporting management strategies (Fulton, Manfredo, & Lipscomb, 1996; Vaske & Donnelly, 1999). The cognitive hierarchy model of human behavior outlines the hierarchical relationship between values, value orientations, attitudes and norms, behavioral intentions, and behaviors (Fulton et al., 1996; Vaske & M. Donnelly, 1999). These elements build upon and influence each other (Figure 1).
Values are considered the foundation in the hierarchy, they are the least likely to change and are central to beliefs (Fulton et al., 1996). Value orientations give meaning to values and create patterns of belief (Vaske & Donnelly, 1999). Wildlife value orientations have been used to predict acceptability of management interventions: wildlife value orientations included domination, prioritizing human needs over wildlife well-being, and mutualism, assigning rights to wildlife (Jacobs, Vaske, & Sijtsma, 2014). Domination versus mutualism wildlife value orientations can result in different attitudes and behaviors toward wildlife (Manfredo, Teel, & Henry, 2009), and can be used to better understand stakeholder attitudes toward wildlife management strategies (Fulton, Manfredo, & Lipscomb, 1996; Jacobs, Vaske, & Sijtsma, 2014).

Attitudes are positive or negative responses related to a specific object (Eagly & Chaiken, 1993). It has been demonstrated that behavioral intentions and behaviors are influenced by attitudes (Eagly & Chaiken, 1993; Homer & Kahle, 1988). We employed this theoretical framework to increase our understanding of values regarding moose, beliefs about moose hunting, attitudes towards specific moose management strategies, and behavioral intention to support specific management strategies.
Understanding values, beliefs, and attitudes regarding moose health in Maine, as well as potential support for wildlife management strategies, will help determine how changing conditions will impact management and the relationships between people and moose in Maine.

### 3.3.2 Theory of Planned Behavior

The Theory of Planned Behavior (TPB) goes beyond the cognitive hierarchy of human behavior to pose three aspects that influence human action: attitudes, subjective norms, and perceived behavioral control (Figure 3.2) (Ajzen, 1991; Hrubes, Ajzen, & Daigle, 2010). These factors contribute to behavioral intention which, along with actual behavioral control, influences behavior (Ajzen, 1991; Hrubes, Ajzen, & Daigle, 2010).

![Figure 3.2. Ajzen (2019) Theory of Planned Behavior](image)

According to the TPB, behavioral beliefs are defined as the subjective interpretation of whether a behavior will produce a given outcome (Ajzen, n.d.). Normative beliefs represent beliefs regarding the expectations of others related to a behavior (Ajzen, n.d.). Control beliefs reflect the perceived amount of control one has over a behavior (Ajzen, n.d.). These foundational beliefs can influence each other and directly influence attitudes, subjective norms, and perceived behavioral control. Attitude toward a behavior reflects the positive or negative value held about a specific behavior (Ajzen, n.d.). Subjective norms encompass the perception of how others would react to you engaging in a behavior (Ajzen, n.d.).
Perceived behavioral control is related to your ability to engage in a behavior (Ajzen, n.d.). Behavioral intention is a result of these constructs and represents an individual’s intent to engage in a specific behavior or action (Ajzen, 1991; Hrubes, Ajzen, & Daigle, 2010). Background factors including individual factors (i.e. age, gender, education, etc.) and social factors (i.e. religion, race, culture, etc.) can also play a role in shaping these constructs (Ajzen, n.d.). The TPB provides a framework for predicting support of management strategies based on attitudes toward specific management strategies, subjective norms regarding support for specific management strategies, and perceived ability to support specific management strategies.

Studies using the TPB to predict hunting behavior and behavior related to wildlife management activities have found that attitudes, subjective norms, and perceptions of behavioral control predict behaviors, albeit in different ways (Hrubes, Ajzen, & Daigle, 2010; Shrestha et al., 2012; Willcox, Giuliano, & Monroe, 2012). A study of outdoor recreationist hunting intentions and behavior found that attitudes, subjective norms, and perceptions of behavioral control all contribute to behavioral intentions, and that intentions had the most influence on behavior when compared to behavioral control (Hrubes, Ajzen, & Daigle, 2010). Another study predicting deer hunting intentions found that perceived behavioral control was the strongest predictor of hunting intentions (Shrestha et al., 2012). A study of rancher wildlife management activity engagement intentions found that attitudes and subjective norms were the best predictors of intentions (Willcox, Giuliano, & Monroe, 2012). An additional study found attitude to be the strongest predictor of behavior intention related to actions associated with wildlife (Miller, 2019). The TPB provides a framework for thinking about the factors that influence behavioral intent as they relate to support of specific moose management strategies and intention to engage in behaviors that support these strategies.

### 3.3.3 Perceived Risk

Perceived risk can be defined as the subjective interpretation of the characteristics and severity of a hazard or danger by an individual (Siegrist & Cvetkovich, 2000) to themselves, their family and friends, or the potential loss of something that they value (Darker, 2013). We focus on perceived risk associated
with the severity of the potential loss of benefits provided by a healthy moose population, as well as the potential loss of moose in Maine. People form risk perceptions from both feelings and logical analysis (Slovic & Peters, 2006), which can both be influenced by characteristics of the risk itself, societal response to the risk, and cultural values (Decker et al., 2010). Perceived risk can influence decision making and therefore special care should be placed on risk communication and messaging (Williams & Noyes, 2007). In this study, risk perceptions are evaluated for specific potential impacts to moose and measured using perceived risk, level of concern regarding specific potential impacts to moose, and opinion that potential impacts to moose are taking place currently.

Management actions and perceptions of the managing agency can influence risk perceptions of wildlife health (Vaske et al., 2004), which can in turn impact decision making when it comes to supporting management (Williams & Noyes, 2007). The degree of trust in managers is a factor that influences risk perceptions (Cvetkovich, & Winter, 2003; Gore et al., 2009; Viklund, 2003). An individual's trust in an agency can be influenced by their perception of the procedural fairness and competence of the agency, therefore confidence in the agency's ability to manage is an important aspect of both overall trust in the agency and related risk perceptions (Riley et al., 2018). Trust has been shown to be highly correlated with acceptance of specific management strategies (Cvetkovich, & Winter, 2003); hence, this study will examine levels of trust towards and confidence in the management agency (i.e., MDIFW) and how these may influence the acceptance of specific moose management strategies.

Along with confidence in management, knowledge has been shown to influence perceptions of risks (Bord & O’Connor, 1992; Flynn et al., 1992; Siegrist & Cvetkovich, 2000). Further, perceived risks are important to understand to develop communication strategies that promote support of healthy wildlife populations (Decker et al., 2010). Wildlife risk perceptions, along with confidence in the agency and knowledge, play a role in people's attitudes and behaviors toward management agencies and can influence the demand for, and acceptance of, management strategies and conservation initiatives (Decker, Lauber, & Siemer, 2002). This study measured levels of current knowledge and perceived risk related to
moose, attitudes, and behavioral intent with the aim of informing communication strategies that address stakeholder concerns and enhances support for moose management strategies in Maine.

3.4 Methods

3.4.1 Study Site

Maine is a rural state located in northern New England, United States. Maine boasts a wide range of ecosystems including rocky coasts, inland forests, and montane regions (Schlawin & Cutko, 2014). Forests cover much of the state, 89% (Butler, 2018), and many bodies of water are present throughout the state including lakes, rivers, and wetlands (The Nature Conservancy [TNC], 2008). Maine contains ideal moose habitat in the form of different aged forests: older stands that provide shelter and regenerating forest stands which provide food (Renecker & Schwartz, 1998). Large water bodies serve as important habitat for moose, primarily as feeding sites in summer, and are plentiful on the landscape (TNC, 2008).

3.4.2 Survey Design and Sampling

In order to understand stakeholder risk perceptions of moose health, values for moose, and behavioral intentions to support specific moose management strategies, a cross-sectional online survey (Lavrakas, 2008) was conducted among outdoor recreationists in Maine, including Maine resident and non-resident moose hunters, non-moose hunters, and non-hunters. A cross-sectional survey design was used to determine characteristics of a certain subset of the population at one point in time (Michaelson & Stacks, 2014; Visser et al., 2000). The online survey instrument (Dillman, 2000) was created and managed using Qualtrics Version 09/2020 (Qualtrics, 2020). The Tailored-Design method allowed us to target samples with email contact information only and mailing address contact information only (Dillman, 2016; Dillman, Christian, & Smyth, 2014). Mailed and emailed invitations were sent out mid September, 2020 and the survey ran from September 23rd to November 13th. Two reminders were sent to potential participants encouraging them to complete the self-administered online questionnaire and to reduce non-response bias (Gillham, 2008; Monroe & Adams, 2012); the 1st and 2nd reminders were sent two weeks and four weeks after the initial invitation, respectively.
Our survey consisted of two samples: (1) Maine outdoor recreationists, and (2) moose hunters. The Maine outdoor recreation sample was obtained through InfoUSA by purchasing a probability random list of mailing addresses (Michaelson & Stacks, 2014) of Maine residents who are active recreationists. The moose hunter sample consisted of 2020 moose hunting permit winners that included email records collected and shared by the MDIFW. Outdoor recreationists were sent an initial letter inviting them to participate in the study, and up to two follow up postcard reminders to increase response rates. Moose hunters were sent an initial email invitation via Qualtrics; up to two follow up emails were automatically sent via Qualtrics to those who had not completed the online questionnaire.

3.4.3 Survey Instrument

The survey instrument consisted primarily of closed-ended questions, in the form of Likert scales, and some open-ended questions to elicit a deeper understanding of participants' perspectives. The questionnaire consisted of four sections: (1) perceptions of current moose population in Maine and personal experience with moose, (2) perceptions of moose health and potential threats to moose populations, (3) attitudes and intentions toward supporting or engaging in different moose management strategies, and (4) sociodemographics.

We measured beliefs, attitudes, and behavioral intentions related to supporting moose management strategies. Beliefs about the current moose population in Maine were measured using 5-pint Likert scales from strongly disagree (1) to strongly agree (5) for the following statements: the moose population in Maine is declining, the moose population in Maine is currently a good size, moose in Maine are healthy, and Maine has enough habitat to sustain the current population. Value of moose hunting as a tool for management was measured using two items on 5-point agreement Likert scales: moose hunting keeps moose populations healthy and moose hunting is a key part of managing moose populations. Attitudes toward moose hunting as a management strategy were measured by asking about comfort with, and perceived impact on moose population health (strong negative to strong positive), of increasing moose hunting on a 5-point Likert scale. We measured behavioral intention by asking about the likelihood of voting to support moose hunting as a management strategy using a 5-point likelihood scale. We also measured behavioral
intention to support three additional potential management strategies on 5-point Likert scales. These included behavioral intentions to vote to support: increased white-tailed deer hunting to reduce moose parasitism, tax breaks to forestry companies who increase commercial forest harvesting to provide moose habitat, and tax breaks to landowners who increase private forest harvesting to provide moose habitat. We measured two behavior intentions regarding likelihood to engage in hunting in the future, intention to hunt moose and intention to hunt white-tailed deer, on a 5-point likelihood scale.

3.4.3.1 Confidence in Agency and Current Knowledge

We measured confidence in MDIFW's management of moose using three items: MDIFW typically makes good decisions regarding moose management, MDIFW properly addresses moose health issues in Maine, and MDIFW sets the right amount of yearly moose hunting permits. These items were measured on 5-point Likert scales from "strongly disagree (1)" to "strongly agree (5)". We calculated a confidence in agency index using the mean score. This index had high reliability with a Cronbach’s $\alpha$ of 0.889.

We measured perceived level of knowledge regarding moose health and management by asking "Do you feel up to date on information regarding current moose population health and management?". We used a 5-point Likert scale from definitely not (1) to definitely yes (5).

3.4.3.2 Risk Perceptions

Risk perceptions were determined by measuring (1) perceived amount of risk, (2) level of concern, and (3) likelihood of current occurrence for a range of potential impacts to moose on 5-point Likert scales. Perceived amount of risk was measured by asking "how much risk do you believe the following factors pose to moose populations in Maine" on a scale from 1, no risk at all, to 5, a great deal of risk for the following factors: decreasing amount of habitat, decreasing habitat quality, increasing diseases in moose, increasing parasites in moose, decreasing winter severity, increasing average annual temperatures, moose competing with white-tailed deer for food, moose competing with other moose for food, moose passing diseases to other moose. Level of concern was measured on a scale from 1, no concern at all, to 5, extreme concern for the question "how much concern do you have that the following factors are having a negative impact on moose in Maine currently" and the following factors: increasing diseases in moose, increasing parasites in
moose, increasing competition with white-tailed deer, increasing competition between moose, decreasing habitat, decreasing habitat quality, moose-vehicle collisions, forestry practices altering habitat, decreasing food availability, moose hunting, increasing average annual temperatures, and climate change. Finally, perceived likelihood of occurrence was measured on a scale from extremely unlikely (1) to extremely likely (5) where respondents were asked "in your opinion, how likely is it that the following things are taking place in Mane currently" for the following factors: the amount of moose habitat is declining, the quality of moose habitat is declining, diseases affecting moose are increasing, parasites affecting moose are increasing, winters are becoming less severe, average annual temperature are increasing, the white-tailed deer population is increasing.

To measured overall risk perceptions related to moose and parasitism we used three items: (1) perceived amount of risk that parasites pose to moose, measured on a 5-point Likert scale (from no risk at all to moose population health to a great deal of risk to moose population health), (2) level of concern related to parasitism of moose, measured on a 5-point Likert scale (from no concern at all to extreme concern), and (3) opinion that parasites affecting moose are currently increasing measured on a 5-point Likert scale (from extremely unlikely to extremely likely). We calculated the mean score to create a parasite risk perception index with the resulting index representing a scale from 1 to 5 with 1 being low parasite risk perception and 5 being high parasite risk perception. Internal consistency, evaluated using Cronbach’s $\alpha$, was considered acceptable ($\alpha = 0.738$) (Taber, 2018).

3.4.4 Survey Quality

The quality of the survey research process and questionnaire development included strategies to address (1) validity, and reliability, and objectivity to reduce measurement error; and (2) increase representativeness via reduction of response error and use of probability sampling designs. Validity concerns the ability of a questionnaire to accurately measure the questions it was designed to answer (Dillman, Christian, & Smyth, 2014; Lee, 2004). The validity of the survey instrument, as well as general instrument design evaluation, was enhanced by conducting a pre-test with graduate students and faculty at UMaine prior to sharing with respondents (Gillham, 2008; Krosnick & Presser, 2010; Turocy, 2002).
Validity was also enhanced by using previously tested measures and scales (DeVellis, 2012; Furr, 2011). Reliability refers to how consistently data is collected and is controlled for by including multiple questions that target different aspects of the same concept (Lee, 2004). Cronbach alpha reliability coefficients were used to test the internal consistency of individual questions (Needham & Vaske, 2008). Objectivity, the limited influence of personal researcher values on the research process, was obtained through the use of a self-administered online questionnaire; development of the survey instrument based on theoretical constructs and current literature as well as pre-testing of the survey instrument by peers to reduce the bias of researcher values in the questionnaire (Davis, 2013). We used the Tailored-Design method to reduce non-response error (Dillman, 2016; Dillman, Christian, & Smyth, 2014); we sent multiple reminders as either email or mailed letter and required respondents to enter unique code when filling out the survey to ensure only one response was collected per household. We included an incentive to complete the survey as an additional effort to reduce non-response bias; respondents had the option to enter to win a $50 gift card through a raffle once they completed the questionnaire (Dillman, 2000). Non-probability sampling was used in the case of the moose hunter sample (Lamm & Lamm, 2019): selection was based on all individuals having won a 2020 moose hunting permit in Maine. Simple random probability sampling was used to obtain our sample of the target population of Maine outdoor recreationists (Daniel, 2012).

3.4.6 Data Management and Analysis

After data collection, the two samples were further categorized into three groups of outdoor recreationists: moose hunters, non-moose hunters, and non-hunters. Moose hunters were categorized as people having won a moose hunting permit for the 2020 season. Non-moose hunters included participants who (1) answered yes to the question "have you ever been hunting for any game species in Maine?" and (2) checked no to the follow up question "have you ever received a moose hunting permit in Maine?". Finally, non-hunters were defined as participants who answered no to the question "have you ever been hunting for any game species in Maine?".

We used the statistical software SPSS (IBM SPSS Statistics Version 27) to manage and analyze the survey data. Data was cleaned and rescaled so that all responses were on 5-point Likert scales with 1
being disagree (or similar low/negative response) and 5 being agree (or similar high/positive response). Descriptive statistics were run to obtain mean scores and response percentages. Normality was assessed using histograms and skew statistics.

Non-response bias was estimated by comparing early respondents (first quarter of respondents) to late respondents (last quarter of respondents) (Filion, 1975; Lankford et al., 1995). We assessed non-response bias by conducting independent samples t-tests (Lankford et al., 1995) using the following variables: familiarity with moose, comfort with increasing moose hunting as a management strategy, behavior intention to vote to support increased moose hunting as a management strategy, parasite risk perception, confidence in agency, and sociodemographics including gender, age, education, political ideology, and income. There were no significant differences between early and late responders for any of the measured variables.

We used one-way ANOVA with Games-Howell post hoc to test for differences between non-hunters, non-moose hunters, and moose hunters for (1) perceptions of the current moose population in Maine, (2) risk perceptions related to potential threats to moose population health, (3) beliefs about moose hunting, (4) individual attitudes and behavioral intentions toward supporting specific moose management strategies, (5) confidence in the management agency, and (6) self-reported current knowledge of moose in Maine at a 95% confidence level (Choudhary & Garg, 2013). We evaluated the data to confirm that it met the assumption of missing completely at random (Van Buuren, 2018). Pairwise deletion was used during the analysis to sample size (Roth, 1994). We tested for equal variance of groups using Levene's statistic (Gastwirth, Gel, & Miao, 2009). We adjusted with the Welch-Satterthwaite test if the assumption of homogeneity of variance was violated (Delacre, Lakens, & Leys, 2017) and analyzed the results using the Games-Howell post hoc test (Ruxton & Beauchamp, 2008). We evaluated skewness for all variables with a cutoff of ± 1.0 (Vaske, 2008). Variables with non-normal distributions were analyzed using the Kruskal-Wallis H test as a nonparametric alternative to the classic one-way ANOVA (Ruxton & Beauchamp, 2008). For all Kruskal-Wallis H tests, Dunn post hoc tests, including Bonferroni adjustments, were run to examine the differences between groups (Ruxton & Beauchamp, 2008). Effect sizes for Welch's t-test results are
reported as $\eta^2$ (Levine & Hullett, 2002). Mean scores are reported for additional variables of interest. Finally, word frequency and association, analyzed in Excel, is reported for the open ended question “in your opinion, what is the single most concerning factor that negatively impacts moose in Maine currently?”.

3.5 Results

3.5.1 Sample Characteristics

A total of 5810 invitations were sent out, 2961 to the Maine recreationists sample and 2849 to the 2020 moose permit winners sample. A total of 1306 responses were collected with an 18% response rate for the Maine recreationists sample and 23% response rate for the moose hunter sample (Table 3.1). A total of 93% of respondents were from Maine. Non-hunters made up 24% of the sample ($N = 308$), non-moose hunters made up 20% of the sample ($N = 264$), and moose hunters made up 56% of the sample ($N = 734$). Moose hunters and non-moose hunters were mostly male, 86% and 84% respectively, while 58% of non-hunters were female. For all groups the majority of respondents were over 60 years old and had completed a 2-year, 4-year, or professional degree. An annual household income of $50,000-$99,999 was the most reported income among all groups. The majority of moose hunters and non-moose hunters considered themselves to be conservative, while non-hunters had a relatively equal split between liberal, moderate, conservative, and undecided political ideologies.

3.5.2 Perceptions of Moose in Maine

Perceptions of the moose population in Maine all had similar neutral mean scores (Table 3.2). These measures included the following statements: the moose population in Maine is declining with the highest mean score ($M = 2.82$), the moose population in Maine is currently a good size ($M = 2.66$), moose in Maine are healthy ($M = 2.63$), and Maine has enough habitat to sustain the current population ($M = 2.26$). There was no significant difference in agreement between groups for the statement that the moose population in Maine is declining ($p = 0.114$) or the statement that the moose population in Maine is currently a good size ($p = 0.151$). Agreement with the statement that moose in Maine are healthy was significantly different ($F(2)= 19.779, p = .000, \eta^2 = .035$) between non-hunters and moose hunters (mean difference = .121), and between non-moose hunters and moose hunters (mean difference = .247); non-
hunters were more likely to agree that moose in Maine are healthy than moose hunters. Agreement with the statement that Maine has enough habitat to sustain the current population was significantly different (F(2) = 18.325, p = .000, \( \eta^2 =.033 \)) between non-hunters and moose hunters (mean difference = .411), and between non-hunters and non-moose hunters (mean difference = .300); non-hunters were more likely to agree that there is enough habitat to sustain the moose population.

3.5.4 Assessment of Moose Hunting as a Management Strategy

In general, respondents believed that moose hunting keeps moose populations healthy (M = 4.05) and that moose hunting is a key part of managing moose populations (M = 4.17). The Kruskal-Wallis H test showed that there was a statistically significant difference in the belief that moose hunting keeps moose populations healthy between non-hunters, non-moose hunters, and moose hunters, H(2)= 103.783, p = 0.000, with a mean rank belief score of 645.66 for moose hunters, 590.10 for non-moose hunters, and 424.59 for non-hunters. Moose hunters were the most likely to believe that moose hunting keeps the moose population healthy while non-hunters were less likely to believe this. For the second measure, moose hunting is a key part of managing moose populations, there was also a statistically significant difference between groups: H(2)= 139.970, p = 0.000, with a mean rank belief score of 662.80 for moose hunters, 560.89 for non-moose hunters, and 407.41 for non-hunters. Moose hunters were more likely to believe that moose hunting is a key part of managing moose populations as compared to non-hunters.
Table 3.1. Mean responses for key measures grouped by relationship with moose hunting. (Scale from strongly disagree = 1 to strongly agree = 5)

<table>
<thead>
<tr>
<th>Measure</th>
<th>Full sample</th>
<th>Moose hunter</th>
<th>Non-moose hunter</th>
<th>Non-hunter</th>
<th>F/H statistic</th>
<th>p-value</th>
<th>η²</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Perceptions of moose in Maine</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>the moose population in Maine is declining</td>
<td>2.82</td>
<td>2.86</td>
<td>2.84</td>
<td>2.70</td>
<td>.114</td>
<td></td>
<td></td>
</tr>
<tr>
<td>the moose population in Maine is currently a good size</td>
<td>2.66</td>
<td>2.63</td>
<td>2.65</td>
<td>2.75</td>
<td>.151</td>
<td></td>
<td></td>
</tr>
<tr>
<td>moose in Maine are healthy</td>
<td>2.63</td>
<td>2.50</td>
<td>2.75</td>
<td>2.88</td>
<td>19.779</td>
<td>.000</td>
<td>.035</td>
</tr>
<tr>
<td>Maine has enough habitat to sustain the current population</td>
<td>2.26</td>
<td>2.16</td>
<td>2.27</td>
<td>2.57</td>
<td>18.325</td>
<td>.000</td>
<td>.033</td>
</tr>
<tr>
<td><strong>Moose hunting beliefs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>moose hunting keeps moose populations healthy</td>
<td>4.05</td>
<td>4.20</td>
<td>4.08</td>
<td>3.66</td>
<td>103.783</td>
<td>.000</td>
<td></td>
</tr>
<tr>
<td>moose hunting is a key part of managing moose populations</td>
<td>4.17</td>
<td>4.36</td>
<td>4.15</td>
<td>3.72</td>
<td>139.970</td>
<td>.000</td>
<td></td>
</tr>
<tr>
<td><strong>Attitude: Perceived impact of moose hunting increase on the health of</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>the moose population</td>
<td>3.29</td>
<td>3.29</td>
<td>3.26</td>
<td>3.30</td>
<td>.861</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Attitude: Comfort with increasing moose hunting to reduce population</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>density and diseases/parasites in moose</td>
<td>3.45</td>
<td>3.52</td>
<td>3.51</td>
<td>3.23</td>
<td>8.820</td>
<td>.000</td>
<td>.014</td>
</tr>
<tr>
<td><strong>Behavior intention to support increasing moose hunting</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.54</td>
<td>3.56</td>
<td>3.54</td>
<td>3.48</td>
<td>.617</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Behavior intention to support increasing white-tailed deer hunting to</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>benefit moose</td>
<td>3.39</td>
<td>3.28</td>
<td>3.44</td>
<td>3.61</td>
<td>9.038</td>
<td>.000</td>
<td>.014</td>
</tr>
<tr>
<td><strong>Behavior intention to support tax breaks to forestry companies who</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>increase commercial forest harvesting to provide moose habitat</td>
<td>3.16</td>
<td>3.18</td>
<td>3.12</td>
<td>3.13</td>
<td>.696</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Behavior intention to support tax breaks to landowners who increase private forest harvesting to provide moose habitat</td>
<td>3.43</td>
<td>3.41</td>
<td>3.45</td>
<td>3.45</td>
<td>.782</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intention to hunt moose in the future</td>
<td>3.55</td>
<td>4.37</td>
<td>3.14</td>
<td>1.93</td>
<td>385.681</td>
<td>.000</td>
<td></td>
</tr>
<tr>
<td>Intention to hunt white-tailed deer in the future</td>
<td>3.77</td>
<td>4.55</td>
<td>3.67</td>
<td>1.90</td>
<td>430.788</td>
<td>.000</td>
<td></td>
</tr>
<tr>
<td>Confidence in agency management of moose index</td>
<td>3.70</td>
<td>3.72</td>
<td>3.79</td>
<td>3.57</td>
<td>6.465</td>
<td>.002</td>
<td>.010</td>
</tr>
<tr>
<td>Perceived current knowledge</td>
<td>3.36</td>
<td>3.71</td>
<td>3.34</td>
<td>2.62</td>
<td>149.804</td>
<td>.000</td>
<td></td>
</tr>
</tbody>
</table>
3.5.5 Attitudes and Behavior Intentions towards Management Strategies

The perceived impact of increasing moose hunting on the health of the moose population, on a scale from having a strong negative impact to a strong positive impact, had a mean of 3.29 and was not significantly different between groups (p = 0.861). Comfort with increasing moose hunting to reduce population density and diseases/parasites in moose had a mean of 3.45 and was found to be significantly different (F(2) = 8.820, p = .000, η² = .014) between non-hunters and moose hunters (mean difference - .292) and between non-hunters and non-moose hunters (mean difference -.280), but not between moose hunters and non-moose hunters. Non-hunters were less comfortable with increasing moose hunting as a management strategy as compared to the other two groups. Behavior intention to vote to support an increase in moose hunting to reduce parasites in moose had a mean of 3.54 and was not significantly different between groups (p = 0.617). Behavior intention to vote to support an increase in white-tailed deer hunting to reduce parasitism in moose has a mean of 3.39 and there was a significant difference (F(2) = 9.038, p = .000, η² = .014) between moose hunters and non-hunters (mean difference -0.333) but not between the other groups. This suggests that moose hunters were more likely to support the idea of increasing white-tailed deer hunting to benefit moose compared to non-hunters. Behavior intentions to support tax breaks to forestry companies who increase commercial forest harvesting to provide moose habitat, and to support tax breaks to landowners who increase private forest harvesting to provide moose habitat, means of 3.16 and 3.43 respectively, with no difference between groups.

Based on the Kruskal-Wallis H test, the intention to hunt moose (H(2) = 385.681, p = .000), and the intention to hunt white-tailed deer (H(2) = 430.788, p = .000) were different between groups. The intention to hunt moose was different between all groups with mean rank belief scores of 662.37 for moose hunters, 434.47 for non-moose hunters, and 242.63 for non-hunters which suggests that moose hunters are the most likely to hunt moose in the future, followed by non-moose hunters, and then non-hunters. Intention to hunt moose had a mean of 4.37 for moose hunters, 3.14 for non-moose hunters, and 1.93 for non-hunters. This indicates that moose hunters intend to continue moose hunting while non-hunters are unlikely to begin. The intention to hunt white-tailed deer was different between all groups.
with mean rank belief scores of 654.49 for moose hunters, 492.62 for non-moose hunters, and 210.11 for non-hunters. This suggests that moose hunters are the most likely to hunt white-tailed deer in the future, followed by non-moose hunters and then non-hunters. The intention to hunt white-tailed deer had a mean of 4.55 for moose hunters, 3.67 for non-moose hunters, and 1.90 for non-hunters, which indicates that moose hunters are very likely to hunt white-tailed deer in the future and non-moose hunters are also likely to hunt white-tailed deer, but that non-hunters are unlikely to begin hunting white-tailed deer.

3.5.6 Confidence in Agency and Current Knowledge

Confidence in the agency in charge of moose management (i.e., MDIFW in this survey) had a mean of 3.70 and was significantly different between groups (F(2) = 6.465, p = .002, η² = .010). Non-hunters and moose hunters were significantly different (mean difference = .152) from each other, as well as non-hunters and non-moose hunters (mean difference = -.222), while there was no difference between moose hunters and non-moose hunters. Non-hunters were less confident in the agency's management of moose than the other two groups. Current knowledge, measured by how up to date on information regarding moose population health and management did respondents feel they were, had a mean score of 3.36. There was a significant difference between all groups based on the Kruskal-Wallis H test, H(2) = 149.804, p = .000, with a mean rank knowledge score of 630.82 for moose hunters, 527.81 for non-moose hunters, and 359.96 for non-hunters.

3.5.3 Risk Perceptions of Moose Health in Maine

When asked how much risk different factors pose to moose in Maine, most factors were perceived as posing moderate risk to moose population health on a scale of 1 (no risk at all) to 5 (a great deal of risk) (Table 3.2). Increasing parasites were perceived as posing the most risk (M = 3.65). The lowest perceived risks to moose were the dynamics of moose competing for food with white-tailed deer (M = 2.37) or other moose (M = 2.38). Concerns related to moose health were moderate on a scale from 1 (no concern at all) to 5 (extreme concern) with the highest concern being about increasing parasites in moose (M = 3.53) and the lowest being moose hunting (M = 1.93) (Table 3.2). The opinion that parasites
affecting moose are increasing was high (M = 3.91). Overall, parasite risk perception was high (M = 3.68) and not statistically significantly different between groups (p = 0.542) (Table 3.2).

Table 3.2. Mean responses for risk perception measures grouped by relationship with moose hunting.

(scale from low risk perception = 1 to high risk perception = 5)

<table>
<thead>
<tr>
<th>Measure</th>
<th>Full sample mean (N)</th>
<th>Moose hunter mean (N)</th>
<th>Non-moose hunter mean (N)</th>
<th>Non-hunter mean (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>How much risk do you believe the following factors pose to moose populations in Maine:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>decreasing amount of habitat</td>
<td>3.07 (1086)</td>
<td>2.86 (595)</td>
<td>3.09 (242)</td>
<td>3.55 (249)</td>
</tr>
<tr>
<td>decreasing habitat quality</td>
<td>3.07 (1072)</td>
<td>2.85 (588)</td>
<td>3.14 (236)</td>
<td>3.54 (248)</td>
</tr>
<tr>
<td>increasing diseases in moose</td>
<td>3.42 (1066)</td>
<td>3.30 (582)</td>
<td>3.50 (235)</td>
<td>3.63 (249)</td>
</tr>
<tr>
<td>increasing parasites in moose</td>
<td>3.65 (1089)</td>
<td>3.58 (604)</td>
<td>3.69 (238)</td>
<td>3.79 (247)</td>
</tr>
<tr>
<td>decreasing winter severity</td>
<td>2.63 (1012)</td>
<td>2.48 (560)</td>
<td>2.51 (223)</td>
<td>3.10 (229)</td>
</tr>
<tr>
<td>increasing average annual temperatures</td>
<td>2.83 (1017)</td>
<td>2.70 (563)</td>
<td>2.74 (215)</td>
<td>3.23 (239)</td>
</tr>
<tr>
<td>moose competing with white-tailed deer for food</td>
<td>2.37 (958)</td>
<td>2.05 (533)</td>
<td>2.34 (217)</td>
<td>3.11 (208)</td>
</tr>
<tr>
<td>moose competing with other moose for food</td>
<td>2.38 (965)</td>
<td>2.13 (541)</td>
<td>2.46 (221)</td>
<td>2.95 (203)</td>
</tr>
<tr>
<td>moose passing diseases to other moose</td>
<td>2.97 (901)</td>
<td>2.79 (502)</td>
<td>3.08 (204)</td>
<td>3.40 (195)</td>
</tr>
<tr>
<td>How much concern do you have that the following factors are having a negative impact on moose in Maine currently:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>increasing diseases in moose</td>
<td>3.19 (1189)</td>
<td>3.17 (656)</td>
<td>3.25 (254)</td>
<td>3.19 (279)</td>
</tr>
<tr>
<td>increasing parasites in moose</td>
<td>3.53 (1185)</td>
<td>3.56 (653)</td>
<td>3.53 (253)</td>
<td>3.47 (279)</td>
</tr>
<tr>
<td>increasing competition with white-tailed deer</td>
<td>2.19 (1185)</td>
<td>1.96 (653)</td>
<td>2.28 (253)</td>
<td>2.64 (279)</td>
</tr>
<tr>
<td>increasing competition between moose</td>
<td>2.19 (1183)</td>
<td>1.98 (651)</td>
<td>2.26 (254)</td>
<td>2.59 (278)</td>
</tr>
<tr>
<td>decreasing habitat</td>
<td>2.86 (1188)</td>
<td>2.62 (655)</td>
<td>2.92 (254)</td>
<td>3.37 (279)</td>
</tr>
<tr>
<td>decreasing habitat quality</td>
<td>2.91 (1179)</td>
<td>2.69 (651)</td>
<td>2.97 (251)</td>
<td>3.37 (277)</td>
</tr>
<tr>
<td>moose-vehicle collisions</td>
<td>2.94 (1188)</td>
<td>2.78 (655)</td>
<td>2.97 (254)</td>
<td>3.32 (279)</td>
</tr>
</tbody>
</table>
Table 3.2 continued

<table>
<thead>
<tr>
<th>Environmental Factor</th>
<th>Mean Score</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>forestry practices altering habitat</td>
<td>2.72 (1185)</td>
<td>2.51 (654) 2.73 (254) 3.21 (277)</td>
</tr>
<tr>
<td>decreasing food availability</td>
<td>2.75 (1184)</td>
<td>2.51 (652) 2.78 (254) 3.29 (278)</td>
</tr>
<tr>
<td>moose hunting</td>
<td>1.93 (1176)</td>
<td>1.68 (650) 1.96 (253) 2.49 (273)</td>
</tr>
<tr>
<td>increasing average annual temperatures</td>
<td>2.63 (1185)</td>
<td>2.46 (652) 2.54 (254) 3.11 (279)</td>
</tr>
<tr>
<td>climate change</td>
<td>2.68 (1186)</td>
<td>2.47 (653) 2.61 (254) 3.23 (279)</td>
</tr>
</tbody>
</table>

In your opinion, how likely is it that the following things are taking place in Maine currently:

<table>
<thead>
<tr>
<th>Phenomenon</th>
<th>Mean Score</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>the amount of moose habitat is declining</td>
<td>3.32 (1251)</td>
<td>3.15 (705) 3.34 (261) 3.71 (285)</td>
</tr>
<tr>
<td>the quality of moose habitat is declining</td>
<td>3.25 (1246)</td>
<td>3.06 (702) 3.29 (260) 3.68 (284)</td>
</tr>
<tr>
<td>diseases affecting moose are increasing</td>
<td>3.70 (1247)</td>
<td>3.64 (701) 3.75 (261) 3.79 (285)</td>
</tr>
<tr>
<td>parasites affecting moose are increasing</td>
<td>3.91 (1246)</td>
<td>3.86 (702) 3.99 (260) 3.96 (284)</td>
</tr>
<tr>
<td>winters are becoming less severe</td>
<td>3.34 (1252)</td>
<td>3.25 (706) 3.34 (261) 3.55 (285)</td>
</tr>
<tr>
<td>average annual temperature are increasing</td>
<td>3.63 (1247)</td>
<td>3.52 (703) 3.57 (260) 3.96 (284)</td>
</tr>
<tr>
<td>the white-tailed deer population is increasing</td>
<td>3.53 (1249)</td>
<td>3.52 (704) 3.52 (261) 3.54 (284)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Parasite risk perception index(^1)</th>
<th>Mean Score</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3.68 (1208)</td>
<td>3.66 (669) 3.72 (257) 3.70 (282)</td>
</tr>
</tbody>
</table>

\(^1\) Mean score index representing a scale from 1 to 5 with 1 being low parasite risk perception and 5 being high parasite risk perception.

We asked the open-ended question "in your opinion, what is the single most concerning factor that negatively impacts moose in Maine currently?" to elicit a deeper understanding of what respondents saw as the factor negatively impacting moose the most. The most mentioned concerns had to do with ticks, winter tick, parasites, disease/parasite infestation and climate change (Figure 3.2). Other concerns were related to human-moose conflicts, decreasing habitat, and decreasing forestry practices that produce moose habitat. Some respondents were also concerned that high moose hunting permit levels and cow (female moose) hunting permits were negatively impacting moose in Maine; in contrast some respondents believed that high moose densities and not enough hunting permits were negatively impacting moose (Figure 3.2).
Figure 3.2. Word cloud depicting the relative frequency of different perceptions of the most concerning factor negatively impacting moose in Maine currently. Size and color correspond to the frequency of occurrence with larger and darker concerns being the most commonly mentioned. Ticks and parasites/diseases were the most common concerns with climate change being frequently linked to these parasites and disease concerns.

3.6 Discussion

This study was implemented to better understand moose hunter, non-moose hunter, and non-hunter beliefs about the moose population and moose hunting in Maine, and their support of moose management strategies. Beliefs about the moose population in Maine were neutral, which suggests that respondents were largely uncertain that moose in Maine are declining, that the moose population is a good size, that moose in Maine are healthy, and that Maine has enough habitat to sustain its current population. Non-hunters were more likely to believe that moose in Maine are healthy while moose hunters were less likely to believe this as compared to non-moose hunters. This could be due to the fact that moose hunters interact more directly with moose and are more likely to see firsthand the impacts of
winter tick on individual moose health. Non-hunters were more likely to believe that Maine has enough habitat to sustain its moose population than moose hunters and non-moose hunters were. These neutral responses suggest that respondents were uncertain about the current status and health of the moose population.

Overall, moose hunting was seen as an important part of managing a healthy moose population with moose hunters being more likely to believe this and non-hunters being less likely. Non-hunters were less comfortable with the idea of increasing moose hunting as a management strategy. Despite this difference in comfort levels, there was no difference between groups regarding perceived impact on moose population health (strong negative-strong positive impact) of increasing moose hunting as a management strategy. This management strategy was seen as likely to have a positive impact on moose population health (M = 3.29) which coincides with research that suggests that lowering population density can have a positive impact on disease and parasite loads (Ellingwood et al., 2020). These results indicate that despite the fact the increasing moose hunting to benefit moose health sounds counterintuitive, respondents understood the justification for the management strategy.

Behavior intentions to support increased moose hunting as a management strategy were relatively high indicating that most people would be likely to support this strategy. There was similar support for increasing white-tailed deer hunting to improve moose health. This high support is similar to other findings that public support of hunting is high and has been high for many years (Decker et al., 2015). Supporting moose health through increasing habitat was also likely to be supported, with higher support if it was done by private landowners versus forestry companies. These levels of support are promising since public acceptance of management can play such a large role in the success of different actions (Zinn et al., 1998).

Intention to hunt moose or white-tailed deer in the future was high for moose hunters and low for non-hunters which is not surprising since moose hunters already engage in hunting activities. Moose hunting as a mechanism for management only works if there are people to hunt moose (MDIFW, 2017; Winkler & Warnke, 2013). Hunting participation has seen declines in the last two decades, with
participation forecasted to continue to decrease (Decker et al., 2015; Winkler & Warnke, 2013). A decline in moose and white-tailed deer hunting participation in Maine would have severe implications for MDIFW's ability to manage moose population density and distribution (Winkler & Warnke, 2013).

Confidence in agency management was high among all groups. Confidence was lower for non-hunters as compared to moose hunters and non-moose hunters; this is not especially surprising since non-hunters are less likely to interact with the agency. Reported current knowledge was different among all groups with moose hunter reporting being the most up to date, followed by non-moose hunters and then non-hunters. Since knowledge can inform risk perceptions (Bord & O’Connor, 1992; Flynn et al., 1992; Siegrist & Cvetkovich, 2000), which can in turn influence confidence in agency management (Gore et al., 2009, Riley et al., 2018, Viklund, 2003), and attitudes toward management strategies, it is notable that there were differences between all groups regarding perceived levels of current knowledge. Despite difference in reported knowledge, perceptions of risks to moose were similar across groups and there was high uncertainty regarding the status of the current moose population in Maine. This suggests that outreach and education related to the status of the moose population, and the relationship between increased hunting and moose health, could increase support of management by people who are uncertain about the status of the population.

The MDIFW has put a lot of energy into communication regarding moose health and winter tick in Maine. They have made an effort to educate the public about the ecology behind increasing moose hunting in order to reduce moose density and therefore reduce winter tick transmission (MDIFW, n.d.-a). Our findings suggest that despite these communication efforts, some stakeholder groups feel more up to date on current moose health information than others. This is an area where outreach could be targeted to specific stakeholder groups to ensure that people who feel less up to date about moose health, in this case non-hunter recreationists, have access to relevant information. While we measured self-reported levels of knowledge, it would be valuable to measure actual knowledge of moose by different stakeholder groups since other studies have found that moose hunters have low knowledge about moose ecology and disease (Vaske et al., 2006). Low knowledge about the role of hunting in managing a healthy moose population
(MDIFW, n.d.-a) might also be limiting strong support for increased hunting. More research is required to understand information sources and knowledge about moose and winter tick ecology in order to evaluate the effectiveness of management communications (Vaske et al., 2006).

Risk perceptions and concerns regarding negative impacts to moose were moderate except for parasite infestation which was high. Increasing parasitism was also seen as the impact most likely to be taking place in Maine currently. This high risk perception related to parasites can likely be attributed to recent communication efforts by the MDIFW and media attention surrounding the impacts of winter ticks on the moose population in Maine (MDIFW, n.d.-a). People might also be seeing heavily infested and sickly looking moose, which could raise awareness and concern. Concerns regarding climate change impacts on moose were low, despite the interconnected nature of winter tick parasitism and a warming climate (Samuel, 2007).

Despite the low concerns regarding climate change and moose health, results from the open-ended questions highlight high concerns about ticks, diseases, and parasites: these impacts were often cited as being related to climate change, increasing temperatures, and/or changes in winter severity in the open-ended responses. This suggests that people are somewhat aware of the potential of climate change to exacerbate interactions between moose and winter tick. This relationship between climate change and ecology knowledge and risk perceptions related to moose health warrants further exploration.

The open-ended question regarding impacts to moose also saw some recurring beliefs that moose hunting reduces the moose population too much and that moose hunting permit increases are motivated solely by the money that they bring in. These beliefs could be contributing to negative attitudes toward the management strategy and low trust in the management agency, both of which can influence potential support of the strategy. While overall confidence in the agency's ability to manage moose was high, these beliefs about the motivation for increasing moose hunting highlights a skepticism of the motivation behind the management decisions regarding moose hunting.

Public support is important and the MDIFW would benefit from continued communication efforts and targeted outreach related to moose ecology and management. Messaging strategies targeting attitudes,
norms, and behavioral intentions toward hunting as a management tool would likely benefit overall support of management strategies involving hunting and help to maintain high hunting participation in the state. Persuasive communication could be used to resolve some of the uncertainty that exists in beliefs about the status and health of the moose population.

3.6.1 Limitations and Future Research

Several limitations of this research should be noted. Since this study only targeted hunters and other types of outdoor recreationists, additional research might explore how Maine residents that do not engage in outdoor recreation perceive moose and their management. Perceived knowledge of moose, as well as personal interest in moose, could also have influenced participation in this study; our results may be indicative of the acceptance of moose management strategies by people with knowledge and/or interest in moose and therefore may not be representative of the larger population of hunters and outdoor recreationists in Maine. Additional research might explore and assess the effectiveness of communications and outreach about moose health and management on influencing perceptions, as well as the role that communication plays in the formation of attitudes toward moose management strategies and trust in the MDIFW.
CHAPTER 4
CLIMATE CHANGE PLANNING IN A COASTAL TOURISM DESTINATION, A
PARTICIPATORY APPROACH

4.1 Introduction

4.1.1 Climate Change, Visitation, and Tourism Supplier Adaptation

Nature-based tourism (NBT) destinations face many challenges and opportunities caused by climate change. NBT relies on natural features for outdoor recreation activities. Coastal NBT destinations are some of the most sensitive tourism destinations due to ecological and socio-economic impacts from climate change (e.g., sea level rise, extreme weather events, flooding, erosion, etc.) (Wong et al., 2013). Climate affects the timing, length, and quality of tourism seasons, which influence visitor destination selection, activity participation, timing of visits, and spending (Perry et al., 2018; Wilkins et al., 2018). Tourism destinations will continue to experience changes in visitation patterns due to climate change (Gossling et al., 2012; McCreary et al., 2019); differential impacts can occur across destinations, with some experiencing increased visitation (i.e., summer destinations in cooler climates) while others facing declines (Fisichelli et al., 2015). NBT suppliers (e.g., restaurants, hotels, tourist operators, etc.) must manage for uncertain climate impacts to natural assets and changes to the visitor flows upon which they rely. Predicting and anticipating shifts in visitor flows and demands resulting from climate change can aid tourism suppliers as they proactively respond to changing visitor expectations and behaviors, helping them provide high quality tourism experiences that also generate economic development (Amelung, Nicholls, & Viner, 2007).

Responding to climate change involves adaptation and mitigation within destinations. Through proactive management, tourism suppliers can offset climate change impacts that may negatively affect visitors, suppliers, and residents within destinations (Atzori, Fyall, & Miller, 2018). Adaptation refers to adjustments in response to climate change impacts to alleviate harm or take advantage of opportunities (Oppenheimer et al., 2014). Local adaptation strategies account for context-specific conditions (e.g., economic, social, environmental) that often lead to more tangible results and policies that benefit local
stakeholders (Picketts et al., 2012; Tribbia & Moser, 2008). Mitigation involves reducing greenhouse gas emissions or enhancing greenhouse gas sinks (Oppenheimer et al., 2014). While mitigation is critical for reducing emissions, adaptation is necessary to cope with current and future climate change impacts at a local scale.

Tourism suppliers may recognize their risk from climate change; however, inaction is common due to many reasons, such as not knowing how to address climate change or not having the resources to adapt (Gifford, 2011; Horne, De Urioste-Stone, & Daigle, in review). Some studies have found that suppliers believe adaptation and mitigation is the responsibility of the government or other organizations rather than tourism suppliers (Miller, Megen, & Buys, 2012); however, there are few policies in place to address climate change within the tourism industry (Jarratt & Davies, 2020). It is therefore important for tourism suppliers to overcome barriers to adaptation and mitigation to ensure destination resilience.

4.1.2 Participatory Workshops for Climate Planning

Participatory planning workshops can serve as a resource to overcome barriers to tourism management and increase tourism supplier capacity to anticipate and respond to climate change impacts. Participatory planning refers to activities that build on existing strategies based on stakeholder needs, concerns, and perceived risks and opportunities (Galvin, 2019). Local stakeholders play a key role in shaping the trajectory of planning efforts (Galvin, 2019). A participatory approach to address climate change can result in system-wide management initiatives, community development, and collaborative decision-making (Chen, Xu, & Lew, 2020). Active participation of diverse stakeholders in climate change planning increases the likelihood that decisions are locally appropriate, accepted by local actors, and include diverse needs and perspectives (Chevalier & Buckles, 2013; Khadka et al., 2018).

Local stakeholders’ ability to adapt to and mitigate emissions that contribute to climate change depends on their understanding of key issues, and their level of involvement in developing strategies to cope with climate change impacts (Ross et al., 2015). Participatory approaches involving municipal, local, and relevant community stakeholders can lead to increased understanding of climate change impacts, enhanced networks of collaboration, ownership of the planning process, and diversified, locally relevant
management solutions (Bonzanigo, Giupponi, & Balbi, 2016; Kim & Kang, 2018; Lépy et al., 2014). Workshops as a participatory method provide opportunities to build and strengthen relationships amongst stakeholders who are engaged in achieving a common goal (Bartels et al., 2013). Despite being called upon to launch climate change planning efforts, local actors are rarely actively engaged with participatory processes (Moser & Ekstrom, 2011). Our work addresses this gap by using a collaborative approach whereby the research team jointly developed participatory climate change planning workshops with tourism partners. Through this collaboration, we co-created a series of participatory workshops to increase tourism climate change planning capacity on Mount Desert Island (MDI), Maine, USA. We sought to engage with, and identify common goals, concerns, and tourism development priorities to support locally driven climate change planning.

4.2. Methods

4.2.1 Study Area

MDI is located along the central coast of Maine and includes Acadia National Park (ANP), one of the most visited destinations in Maine (Figure 1). In 2019, ANP recorded 3.4 million visitations, the majority occurring June-October (NPS, 2019). Popular recreational activities on MDI include hiking, walking, bicycling, camping, sea kayaking, and canoeing (MBPL, 2020). As a result of climate change, MDI will experience rising annual temperatures and precipitation, increasing extreme weather events, rising sea levels, and growing number of cases of tick-borne diseases (Fernandez et al., 2020). Summer and shoulder season (e.g., spring and fall) visitation is expected to grow on MDI due to rising temperatures (Fischelli et al., 2015). Increased visitation on MDI has resulted in negative impacts on vegetation and wildlife (MDIFW, 2015), as well as traffic congestion, budgeting and staffing concerns, and erosion in high-use recreation areas (Star et al., 2016); however, warmer summer temperatures may increase revenue for local businesses as increased temperatures have been associated with a rise in tourism-related spending (Wilkins et al., 2018).

The tourism destination of MDI includes a diversity of stakeholder groups, such as residents and suppliers (e.g., businesses, non-profits, municipal officials, the National Park Service). We focused on
one stakeholder group, tourism suppliers, for these workshops given that they are likely to experience impacts first-hand, often have limited resources to respond to climate change, and have a critical role in addressing climate change impacts and ensuring tourism supply meets demand. Multiple climate change initiatives exist in the area, several of which are spearheaded by A Climate to Thrive (ACTT), a non-profit climate change planning and mitigation organization on MDI. Other groups, like the Bar Harbor Climate Emergency Task Force and ANP, have contributed to climate change communication and planning efforts, especially as they relate to ecological changes. Our workshops provided a unique opportunity for tourism suppliers to discuss climate change impacts related specifically to tourism on MDI, incorporating socio-ecological concerns.

Figure 4.1. Location of study area, Mount Desert Island, in the context of US and Maine with town boundaries and ANP boundaries (green). Letters correspond to the locations of the photos
on the right including (a) downtown Bar Harbor (b) coastline view from the Park Loop road, and (c) a view from a mountain in Southwest Harbor.

4.2.2 Workshop Planning and Implementation

The research team collaborated with tourism partners, such as business owners, non-profits, and NPS employees, to develop and implement a workshop framework to identify climate change planning priorities for the tourism industry on MDI. We identified and recruited members of the planning team using existing relationships with tourism suppliers, recommendations from these contacts, and targeted outreach to different supplier groups to ensure diverse representation. Workshop planning commenced in January 2021 over Zoom to discuss and refine appropriate workshop goals and activities, discuss barriers to implementation, and develop a participant recruitment strategy. Partners recruited workshop participants through existing listservs (e.g., Chambers of Commerce) and local media outlets (i.e., newsletters, newspaper); different recruitment strategies reached different tourism supplier groups. Workshop attendees included business owners (3), ANP staff (4), non-profit representatives (2), a town official (1), and a climate scientist (1). We had 11 participants on day 1 and 9 participants on day 2 (though participation at both workshops was encouraged, not all participants were able to attend the two days). We facilitated two virtual half-day Zoom workshops, one week apart, in the spring of 2021. The first workshop sought to develop and prioritize a list of local climate change impacts to tourism on MDI. The second workshop built upon topics discussed at workshop 1 to generate and evaluate adaptation and mitigation planning priorities (Table 4.1).

Table 4.1. Overview of workshop objectives and activities conducted each day, and duration of each activity.

<table>
<thead>
<tr>
<th>Objectives</th>
<th>Activities</th>
<th>Time (min.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Describe the purpose of the workshops, share ground rules, and introduce participants and facilitators</td>
<td>Researcher presentation, Round robin introductions</td>
<td>50</td>
</tr>
<tr>
<td>Activity</td>
<td>Facilitation Method</td>
<td>Time</td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>--------------------------------------------</td>
<td>-------</td>
</tr>
<tr>
<td>Share data on climate change impacts and visitation projections</td>
<td>Researcher presentation, Question and answer session</td>
<td>30</td>
</tr>
<tr>
<td>Develop and refine a list of climate change impacts to tourism on MDI</td>
<td>Small group discussions</td>
<td>25</td>
</tr>
<tr>
<td>Prioritize climate change impacts and opportunities according to significance to tourism and ease of implementation by participants</td>
<td>Dot voting (two rounds)</td>
<td>15</td>
</tr>
<tr>
<td>Create a preliminary list of ongoing adaptation and mitigation actions and to identify where actions are lacking</td>
<td>Free writing activity to identify current and needed climate change actions</td>
<td>10</td>
</tr>
<tr>
<td>Summarize workshop findings</td>
<td>Researcher presentation, Large group discussion</td>
<td>10</td>
</tr>
</tbody>
</table>

**Day 2**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Facilitation Method</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Re-introduce participants and facilitators, and brainstorm existing community resources</td>
<td>Researcher presentation, Round robin introductions</td>
<td>30</td>
</tr>
<tr>
<td>Share identified priority concerns and impacts from day 1 and define terminology</td>
<td>Researcher presentation, Question and answer session</td>
<td>20</td>
</tr>
<tr>
<td>Create a list of planning priorities based on day 1 activities</td>
<td>Small group discussions</td>
<td>50</td>
</tr>
<tr>
<td>Brainstorm existing strengths, barriers, and resources for identified actions</td>
<td>Large group discussion</td>
<td>20</td>
</tr>
<tr>
<td>Evaluate planning priorities and action strategies that could be implemented in the future</td>
<td>Dot voting (two rounds)</td>
<td>10</td>
</tr>
<tr>
<td>Summarize identified priorities, outline potential steps forward, and highlight potential community collaborations</td>
<td>Researcher presentation</td>
<td>10</td>
</tr>
</tbody>
</table>

**4.2.2.1 Workshop 1: Building shared understanding, identifying, and ranking local climate change impacts**

We began our workshops with a presentation on climate change impacts on MDI, including effects on the environment and tourism industry identified through relevant literature and research (Birkel & Mayewski, 2018; Fernandez et al., 2020). We incorporated a round robin activity for participants to
share their observations and experiences related to climate change; this activity contributed to our creating a shared baseline knowledge before proceeding with other activities. Understanding climate change impacts to MDI’s tourism system and related stakeholder concerns was necessary to begin identifying shared planning priorities. We created an initial list of local climate change impacts from the literature and participants’ experiences. In breakout rooms, using a modified nominal group technique (NGT) (Delbecq, Ven de Ven, & Gustafson, 1975), participants added impacts to the initial list. The lists from the breakout groups were compiled into one comprehensive list during a full-group session where participants further clarified items. We facilitated two dot voting exercises to identify (1) impacts that were top concerns and (2) impacts that could most easily and immediately be addressed by MDI tourism suppliers. Dot voting is a method to prioritize choices; participants are allocated a number of votes (dots) that they assign to their top choices (Gray et al., 2020). At the end of the dot votes, the impacts with the most votes were ones that participants considered to be of highest planning priority and the most readily addressable.

4.2.2.2 Workshop 2: Generating and ranking planning priorities

The purpose of workshop 2 was to rank locally relevant planning priorities to address climate change impacts to tourism on MDI identified in workshop 1. In small groups, participants brainstormed planning priorities that addressed the identified climate change impacts. Representatives from small groups shared their ideas in a full-group discussion, resulting in a collective list of potential planning priorities. For each planning priority, participants identified specific actions that would need to occur, along with community resources, strengths, and barriers to implementation. Participants used dot voting to rank the priorities that needed to be addressed immediately or were most pressing, while taking strengths and weaknesses of the tourism destination into consideration. The voting exercise resulted in a list of locally relevant, feasible planning priorities to address the top climate change concerns to tourism on MDI. At the end of workshop 2, participants indicated climate change impacts they were most interested in actively addressing, resulting in informal working groups for the future.
4.2.3 Data Analysis

Workshop artifacts (i.e., Google documents, Google form free-write outputs, dot vote results, and recordings) were analyzed in Excel. We analyzed dot vote results in Excel to determine the highest ranked concerns and planning priorities (Delbecq, Van de Ven, & Gustafson, 1975). For text artifacts and recordings, we used NVivo 13 to identify patterns using qualitative coding exploratory analyses (i.e., word clouds, frequencies). Researchers coded transcripts independently for patterns and then met to discuss and ensure our interpretations accurately reflected participant ideas (Miles, Huberman, & Saldaña, 2020).

4.3. Results

4.3.1 Workshop 1: Identifying and Ranking Local Climate Change Impacts

Some impacts identified in breakout groups were refined during full-group discussions. For example, participants listed increasing visitation but decided to include an additional impact to address shifts in the timing of visitation, offering a nuanced understanding of the management challenges and opportunities facing suppliers. Impacts and opportunities fell into six categories: (1) increasing heat and temperatures, (2) changes to precipitation and water resources, (3) changes to flora and fauna, (4) unpredictability of impacts, (5) changes in visitation, and (6) climate change impacts on management and human well-being (Supplemental Table A).

The dot voting tool resulted in the ranking of the five most significant climate change impacts to the tourism system on MDI and that the top five impacts most readily able to address (Table 2). Top climate change challenges and opportunities included increasing visitation, the opportunity to model sustainability, seasonal shifts in visitation, increasing pressure on housing, and fire risk in summer, respectively. The impacts easiest to address included the opportunity to model sustainability, improving infrastructure for island access, managing for increasing visitation, changing patterns of winter outdoor recreation, and increasing pressure on housing availability and land use, respectively.
Table 4.2. Ranking of climate change items by significance of their ability to impact tourism on MDI and easiest to address (top five rankings).

<table>
<thead>
<tr>
<th>Ranking</th>
<th>Most Significant Climate Change Impacts and Opportunities to Tourism on MDI</th>
<th>Easiest Climate Change Impacts for Tourism System to Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Increasing visitation</td>
<td>Opportunity to model sustainability (mitigation actions)</td>
</tr>
<tr>
<td>2</td>
<td>Opportunity to model sustainability (mitigation actions)</td>
<td>Challenges with island access from flooding/extreme weather events</td>
</tr>
<tr>
<td>3</td>
<td>Shifts in seasonality of visitation</td>
<td>Increasing visitation</td>
</tr>
<tr>
<td>4</td>
<td>Increasing pressure on housing availability and land use</td>
<td>Different patterns of winter outdoor recreation</td>
</tr>
<tr>
<td>5</td>
<td>Higher fire risk in summer</td>
<td>Increasing pressure on housing availability and land use</td>
</tr>
</tbody>
</table>

The top two impacts were (1) changes in visitation patterns and (2) modeling sustainability. The discussion about changes in visitation patterns included things such as increasing visitor numbers, shifts in the timing of visitation (i.e., seeing more visitors during off-peak seasons), and changing visitor behaviors (i.e., selecting different recreation sites, pursuing different recreational activities). As shared by several participants and highlighted by a non-profit leader, modeling sustainability could support the desire to become a low carbon tourism destination that could further benefit the resilience of the industry:

“We talked a lot about the opportunity to establish MDI as an epicenter of green tourism and a model of a community that, you know, has really entrenched sustainability practices, has addressed resilience, and is actively participating in climate solutions. And I think that there's going to be more and more of a draw for people to travel and experience places like that.”

(Climate change nonprofit leader)
4.3.1.1 Key patterns from workshop 1

Some key ideas that emerged from day 1, included the varied experiences of different stakeholders with climate change, issues of unpredictability and uncertainty, and tipping points. Workshop participants distinguished between the ways climate change impacts are experienced by residents and local suppliers compared to visitors. As an example, participants used an analogy of a restaurant where the front of the house represents tourists, and the back of the house represents residents and suppliers. There will likely be impacts that the front of the house notices while the back of the house is unaffected, and vice versa. Accommodating increased visitation requires a comprehensive planning that serves both the back and front of the house. Opportunities for climate change adaptation must address a range of stakeholder experiences while providing benefits for MDI communities as visitation fluctuates/varies/changes.

Participants highlighted the unpredictability of climate change impacts on MDI. For example, it is difficult to plan for winter tourism when conditions change daily and year-to-year. Unpredictable conditions have devastating consequences for tourists who are ill-prepared for the weather, as workshop participants recalled a fatal winter recreation accident occurring last year. It is also difficult for suppliers to adapt to changes in daily and yearly winter conditions as they must be prepared to accommodate a variety of activities depending on snow availability (e.g., skiing, snowshoeing, hiking, fat biking, etc.).

Some participants felt that adapting to climate change was complicated by the fact that not all impacts occur on the same schedule. For example, some impacts may occur in the short-term (e.g., extreme weather events, storm surges, etc.), while others are longer-term (e.g., increasing average annual temperatures, sea level rise, etc.). This temporal lens introduces the idea of tipping points related to tourism and climate change. While multiple definitions of tipping points exist, they describe a threshold being passed, resulting in the internal system dynamics becoming uncontrollable, unprecedented, and unpredictable (van Nes et al., 2016). While tourism may increase in the summer as visitors escape warmer areas, there may be an upper temperature threshold at which point tourism decreases, as described by a workshop participant:
“We're going to reach this tipping point, where we're actually gonna have to worry about not enough visitation to support the businesses that support the community.” (Hospitality business owner)

Participants highlighted a concern of reaching a threshold whereby MDI is no longer a desirable destination in terms of climate. Considering tourism and climate change together is critical to address the challenges of planning for uncertain conditions. Specifically, planning for potential visitation increases and decreases will be important in the long-term.

4.3.2 Workshop 2: Generating and Ranking Planning Priorities

We used small group discussions of adaptation and mitigation planning priorities to address previously identified climate change impacts. Then, as a whole group, we classified planning priorities into four categories. The following paragraphs elaborate on the four priority planning areas to address two key impacts from day 1, modeling sustainability and increasing visitation: (1) communication and education, (2) climate friendly transportation infrastructure, (3) collection, analysis, and sharing of visitor data, and (4) building the capacity of MDI’s hospitality sector.

Participants identified the need for a cohesive educational message to both (1) reduce individual carbon footprints, and (2) enhance winter recreation safety. According to participants, communication can influence visitor actions while creating benefits to MDI communities (e.g., fewer emissions because visitors are using public transportation instead of personal vehicles). Ideally, cohesive messages across visitor audiences would share climate change information and create opportunities to positively shape everyone’s experiences:

“I think with each one of those contacts with a local [supplier] that's the opportunity for the local [supplier] to try to shape how that visitor visits the park [...] to make it better for all of us.”

(Tourism non-profit leader)

Participants viewed a centralized messaging campaign as critical to promoting more climate friendly visitor behaviors (e.g., taking public transportation). Participants expressed the need for a larger education campaign during off-seasons, as a greater number of visitors are recreating during this time. According to
participants, more accidents were happening during winter due to what they believed was a lack of preparedness, awareness, and information to recreate safely. Most workshop attendees felt more communication with off-season recreationists would help increase safety and preparedness.

Most MDI visitors arrive via personal vehicle, leading to increased problems with traffic congestion, crowding at parking areas, and growing emissions and pollution. Although a local bus system, The Island Explorer, and a handful of electric vehicle (EV) charging stations currently exist on MDI, workshop participants described additional enhancements to transportation infrastructure they would like to see. Potential improvements include creating bike lanes, increasing the number of EV charging stations, enhancing the capacity of The Island Explorer, and creating pedestrian zones by limiting vehicles in downtown Bar Harbor (a popular area for foot traffic and parking). According to participants, improvements in public transportation should be paired with communication campaigns to encourage use by visitors.

Participants acknowledged the value that increased visitor data (e.g., numbers, characteristics, preferences, etc.) collection could have on addressing visitation challenges. Participants wanted to share data across tourism stakeholder groups on MDI. To do this, participants wanted to create a centralized database where tourism stakeholders could access visitor data to aid planning.

Tourism suppliers on MDI must build its capacity to handle shifts in visitation numbers, travel behavior, and traveler type. Many participants described encounters between tourism suppliers and visitors as important opportunities for communication and education about climate-friendly behaviors, climate change impacts, and related safety information.

4.3.2.1 Key patterns from workshop 2

During the second workshop, we discussed barriers to implementing planning priorities, such as lack of funds, time constraints, limited appropriate infrastructure, and lack of formal leadership within the tourism industry to coordinate climate change adaptation. The expanding tourism season exacerbates these barriers and places added pressure on tourism suppliers to overcome challenges individually. Funding was a common barrier preventing climate change action. Further, multiple participants
emphasized the need for infrastructure and facilities to be renovated for year-round use, and new facilities be developed to accommodate increased visitation and staff housing requirements. Although multiple opportunities to secure funding exist, tourism suppliers need to be aware about them and have the capacity to apply for funding. As participants mentioned, grants are typically available for innovations and start-up costs, not for long-term maintenance or updating existing programs. Instead, user fees and taxes are used to maintain programs and tourism resources (e.g., natural and cultural recreation sites). Many participants described how visitors are dissatisfied with a recent price increase in ANP entrance fees to support resource management needs. Despite a concerted effort to explain to visitors the rationale for a higher entrance fee, workshop participants described receiving visitor complaints.

Participants took on multiple roles on MDI to run their businesses and support community development efforts. Although participants were interested and engaged in issues of climate change and tourism planning, priority obligations (e.g., family, business, etc.) took precedence. The ultimate barrier identified by participants was the lack of a dedicated leadership working on climate change and tourism issues. Participants repeatedly agreed that a formal dedicated role is necessary to advance tourism climate change planning, adaptation, and mitigation strategies. Ideally, participants wanted this position to coordinate efforts on cohesive messaging, to identify potential funding, and to relieve stress and obligations from individual suppliers.

4.4. Discussion

Tourism suppliers play a key role in supporting and leading climate change adaptation and mitigation actions within tourism destinations; however, tourism suppliers are rarely involved in participatory planning processes that consider local realities, goals, and available resources (Galvin, 2019). To overcome traditional power dynamics and ensure locally relevant planning efforts (Picketts et al., 2012), we co-created a series of participatory workshops with tourism partners to address climate change planning within a coastal tourism destination. Planning for climate change is important for tourism suppliers to proactively minimize challenges and take advantage of opportunities. As climate change alters visitation patterns, changes in visitor markets may require different tourism structures and
product offerings that require adjustments on the part of tourism suppliers (Lew & Cheer, 2018). MDI will likely benefit from warming temperatures and increased visitation (Fisichelli et al., 2015), while presenting increased challenges in managing the negative impacts of crowding on the visitor experience, natural resources, and local residents (Gonzales, Coromina, & Gali, 2018). Previous studies have found that tourism suppliers had limited capacities to prioritize climate change actions (Tervo-kankare, Kaján, & Saarinen, 2018). Planning efforts require time, a cohesive and unified message, and coordination and engagement from multiple stakeholders (Kelly & Williams, 2007). Kelly and Williams’ findings are similar to our results where tourism suppliers, while aware of the importance of responding to climate change, acknowledged their many roles within the community and therefore limited capacities to prioritize climate actions. In our study, the researchers served as a catalyst (Galvin, 2019) for suppliers to proactively engage with the tourism planning process on MDI. Our results provide insights on a participatory workshop framework to prioritize local climate change impacts and actions within the tourism industry.

4.4.1 Collaboration and Communication across Stakeholders Enhance Tourism Planning for Climate Change

Responding to climate change will be intricate given the complexity of climate and tourism systems (Moreno & Becken, 2009); therefore, a cooperative approach is required to address stakeholder barriers to action (Pinkse & Kolk, 2012; Jopp, Delacy, & Mair, 2010). Participants often mentioned the challenges of creating a unified front to take advantage of opportunities and address challenges associated with climate change. They noted that collaboration would help overcome barriers such as time constraints, limited financial support, inadequate infrastructure, uncertainty of climate change impacts on the tourism system, and lack of centralized-formal leadership structure. Similar barriers have been identified across tourism destinations (Horne, De Urioste-Stone, & Daigle, 2018; Turton et al., 2010). While there is no single organization or individual capable of addressing climate change within a destination, collaboration across MDI was viewed as a way to overcome barriers to implement tourism planning priorities.
The workshop approach served as a catalyst for cooperation by engaging tourism actors in a dialogue to develop locally relevant solutions (Moser & Ekstrom, 2011) while seeking to foster both individual and collective capacity to proactively respond to change (Filimonau & De Coteau, 2020). It is important to create opportunities, such as participatory workshops, to allow community members to openly communicate, exchange relevant information, and better understand what needs to be addressed to develop solutions (Moser, 2010). Participatory workshops can also create a space where different perspectives, knowledge systems, and experiences can be shared to ensure multiple stakeholder voices inform the planning process (Ross et al., 2015). While many participants had previously interacted, the workshops created a space for jointly addressing the specific needs of the destination and co-developing actionable knowledge to respond to uncertain climate change impacts (Wyss, Luthe, & Abegg, 2015).

Communication has been recognized as an effective way to implement adaptation and mitigation efforts by building awareness and dialogue around climate change (UNFCC, 2021) and was recognized by workshop participants as central to all four planning priorities discussed. There is growing literature in the field of ‘green communication’ to share sustainability efforts occurring at a destination with visitors (Holleran, 2008; Peattie & Crane, 2005). Workshop participants hoped to attract visitors based on shared values and sustainability messages that encourage certain visitor behaviors (Cucculelli & Goffi, 2016; Hanna et al., 2018). Other tourism destinations found that communicating and fostering sustainability behaviors among visitors can play a role in sustainable development (Paunović & Jovanović, 2017; Welford & Ytterhus, 2004). A holistic approach in communications and promotions may involve messages that integrate social equity, environmental protection, local livelihoods, and safety, while also considering local cultural, social, and environmental values (Jamrozy, 2007; Wheeler, Frost, & Weiler, 2011).

Recreationist safety was another important communication issue for participants, and has been identified as a key concern among other tourism destinations (Hallmann, Müller, & Feiler, 2014; Pyke et al., 2016; Saunders et al., 2019). Communication efforts that describe the risks of recreation can promote visitor safety (Wang & Lopez, 2020). Tourism destinations may consider new avenues for visitor safety
communication. For example, social media may provide a relatively inexpensive approach to communication, destination promotions that describe current opportunities, and strengthen the sustainable image of the destination (Kiráľová & Pavlíčeka, 2015).

4.4.2 Tipping Points can Result in Positive, then Negative Impacts to the MDI Tourism System

Maine is dependent on tourism to support economic development, with MDI serving as an important tourist destination (Maine Office of Tourism, 2019b) that is vulnerable to climate change. Incorporating ecological and social dimensions of climate change will be critical for tourism planning (Moreno & Becken, 2009). Natural resource-dependent recreation areas have carrying capacities (e.g., visitation they can accommodate) that depend on characteristics of the area (e.g., infrastructure, natural resources, etc.) (Dvarskas, 2017). Exceeding a destination’s carrying capacity can lead to negative socio-ecological impacts. For example, Dvarskas (2017) found that changes in water quality due to sustained over-tourism resulted in decreased desirability of beach destinations. Tradeoffs exist when considering how to address infrastructure needs, increased staffing, and modeling sustainability, as it is unclear how certain strategies may affect carrying capacity of natural, built, and human environments (Dawson & Scott, 2010; Atzori, Fyall, & Miller, 2018).

In relation to socio-ecological carrying capacities, participants discussed tipping points within the tourism industry. In the context of tourism, tipping points might include a shift in a destination’s visitor appeal from desirable to undesirable. For example, while increased visitation brings positive economic impacts (i.e., revenue), there is also the potential for visitation to reach a tipping point, such that visitors to MDI place unsustainable pressure on natural resources. Several tourism studies suggest that tipping points can alter visitation patterns (e.g., by increasing off-season tourism numbers, or decreasing annual visitation when a threshold is surpassed) (Coldrey & Turpie, 2020; Scott, Jones, & Konopek, 2007), though this does not appear to be the case in every tourism destination (Smith et al., 2016). Although in the short and medium terms MDI may be a suitable summer destination in comparison to southern destinations experiencing hotter summers, tourism destinations must plan for future declines if climate becomes “too warm” or less attractive to visitors seeking cooler destinations (Dawson & Scott, 2010).
4.4.3 MDI’s Opportunity to Model Sustainable Tourism Destination Development

Workshop participants recognized that tourism contributes to climate change through energy consumption and greenhouse gas emissions. Participants saw an opportunity at the intersection of climate change and tourism to develop a more sustainable system that reduces MDI's contributions to climate change and encourages tourists to engage in climate friendly visitation practices. Not only would these actions help reduce MDI's carbon footprint, but participants felt they could also serve as an educational opportunity for visitors and attract tourists looking for sustainable and/or green tourism destinations.

Transportation to a destination usually constitutes the greatest individual visitor carbon footprint while on travel, resulting in large amounts of greenhouse gas emissions that negatively impact the environment and exacerbate climate change (Kelly & Williams, 2007). This paradox of tourism, in which the act of tourism degrades the destination directly or indirectly, has led to initiatives of sustainable tourism development that centers in promoting energy efficiency (World Commission on Environment and Development, 1987). While sustainable tourism has many definitions and operationalizations (Hardy, Pearson, & Merz, 2002; Johnston & Tyrrell, 2005) recent approaches have focused on bolstering tourism destination resilience to climate change to enhance social, economic and environmental sustainability. The themes of ‘green’ and ‘sustainable’ tourism destinations have been recognized by other tourism suppliers in previous studies as a primary way to address climate change impacts (Dodds & Graci, 2009; Turton et al., 2010). The development of more sustainable energy systems and transportation strategies would support the future of tourism to MDI and benefit both tourism and the local community.

Community involvement is key to creating sustainable practices that support current and future tourism development (Graci, 2013). Our results highlight multiple community organizations (i.e., ACTT, ANP) and engaged citizens that are currently invested in discussing and implementing sustainable development and climate change mitigation actions on MDI. Creating lasting practices that reduce emissions requires community collaboration and stakeholder involvement (Hardy, Pearson, & Merz, 2002). Current community collaboration and engagement in MDI suggests that there are already strong foundations for successful future sustainable tourism development.
4.4.4 Study Limitations and Future Actions

Although relevant, the planning efforts we conducted engaged a small sub-sample of tourism suppliers in the destination; future workshops should include a greater diversity of tourism stakeholders. Participatory climate change planning could involve MDI residents, who often have differing attitudes toward tourism, and may derive limited benefits from tourism (Goeldner & Ritchie, 2012; Martin, Martinez, & Fernandez, 2018). Including residents in the tourism planning process can reduce negative attitudes and impacts on communities, while ensuring that tourism development meets the needs of locals (Gunn & Var, 2002). Workshop participants remarked that collaborating with non-local tourism actors, would be crucial in creating a cohesive promotional message for MDI as visitors currently seek destination information from various local and non-local sources. Including state tourism planning and marketing experts in future planning efforts could help create a single, cohesive message to promote desired visitor behaviors. For example, one workshop participant described non-local marketing materials about seeing the sunrise from atop Cadillac Mountain; however, local suppliers noted that this attraction is overcrowded and wished marketing materials limited advertisement of this visitor experience. We sent an evaluation questionnaire to participants and received positive feedback, but due to a low response rate (n=3) we did not include the results in this paper. Future research should focus on evaluating the long-term efficacy of participatory approaches to tourism planning by following up with workshop participants to assess sustained efforts resulting from the workshops (Jopp, Delacy, & Mair, 2010). Specifically, we can examine progress addressing impacts identified in Supplemental Table 1, such as creating cohesive communication materials, preparing for seasonal shifts in visitation, increasing housing availability for workers and residents, and improving infrastructure for island access threatened by climate change.

4.5. Conclusion

Our participatory approach to tourism climate change planning was a method aimed at co-developing locally relevant solutions with tourism suppliers. Through our workshops we found that tourism suppliers successfully engaged and communicated with one another about climate change planning during this workshop series. Co-creating the workshop series through a planning committee
resulted in fruitful partnership between the research team and tourism partners, which addressed locally relevant priorities. The participatory workshops gave tourism suppliers a leading role in shaping the destination planning process. Tourism destination planning is important to alleviate negative socio-ecological climate change impacts, ensure a positive visitor experience, and serve the needs of communities. Participatory planning can also help increase destination readiness to adapt to and mitigate the effects of climate change, thereby increasing destination sustainability. Our process of participatory workshop development and implementation can serve as a model to other tourism stakeholders seeking to address climate change at a destination level, as well as to natural resource planners more broadly.
CHAPTER 5
CONCLUSION

This thesis research used a range of methods to evaluate dynamics of the human-moose social-ecological system in Maine. This interdisciplinary perspective provided an opportunity to consider moose landscape use, stakeholder views of moose and their management, and tourism destination climate change planning. Climate change will have a wide range of impacts in Maine, including impacts to moose, moose related recreation, and nature-based tourism (Fernandez et al., 2020). These systems benefit from studies that consider their complex interrelated relationships. An increased understanding of how moose health and landscape use will be modified as a result of climate change will inform related changes to the relationship between people and moose in Maine. These relationships include the reliance on moose for sustenance, culture, and recreation of Maine residents as well as out-of-state visitors.

5.1 Integration of research

Chapter two of this thesis presented an examination of winter moose habitat selection and influence of variable winter weather conditions. Chapter three presented an overview of moose hunter, non-moose hunter, and non-hunter Maine recreationist perceptions of moose health, hunting, and management, as well as evaluated potential support of increased moose hunting as a management strategy. Chapter four provided methods and an overview of community based climate change planning for a tourism destination using participatory workshops. These chapters contribute to our broader understanding of moose in Maine, implications for how climate change could alter social and ecological relationships with moose, and an approach for planning for changes in nature-based tourism destinations.

When considering ecological dynamics of moose on the Maine landscape, our findings suggest that reduced snow density can lead to increased selection for regenerating habitat in winter. This is especially pertinent in Maine where temperatures are projected to increase and snowfall is projected to decrease because of climate change (Fernandez et al., 2020). Moose are known to select for habitat that includes regenerating forest stands and the possibility of increased selection at the home range scale during winters with less snow could lead to changes in the relationship between moose browsing and
forest regeneration, in addition to the spatial distribution of moose. As climate change begins to impact Maine's winter weather conditions, the way moose interact with the landscape will also change. Mild winters have the potential to increase forage availability for moose through the higher use of regenerating forests, but they also have the potential to increase disease and parasite stressors since warmer winters have been cited as facilitating increased parasite transmission from white-tailed deer to moose (Lankester 2010). Our results from Chapter 3 suggest that stakeholders don't perceive climate change to be a major threat to moose in Maine currently, but parasitism was seen as posing the most risk to moose health. Since climate change and increasing parasitism in moose is inherently linked, it was surprising that climate change was not perceived as posing a similar risk to moose as parasitism. This could be due to the polarized and political lenses that have manipulated climate change beliefs in the United States. Moose are an important species in Maine that contribute to the ecology, economy, and culture of the state; these relationships are dependent on a healthy moose population and a strong understanding of how moose populations will respond to climate change. Understanding the complex relationships between the moose population, weather conditions, and habitat use will be important for adapting management strategies, communicating with stakeholders, and maintaining a healthy moose population in Maine.

Management is an important aspect of keeping the Maine moose population healthy, and hunting is a primary tool that the MDIFW utilizes to manage population density of both moose and white-tailed deer (MDIFW, 2017). Changes in the moose population can alter management strategies, and therefore influence cultural and recreational opportunities including moose hunting and viewing. Stakeholder perceptions of moose population health and attitudes toward management can help or hinder management, in part through vocal support or protest of actions. Chapter three highlighted the fact that differences exist in perceptions about moose and management based on experience with hunting and moose hunting. Overall, there was support for increased moose hunting as a management strategy, despite the controversy of increasing moose hunting for some people. Since managing moose includes moose hunting permits, changing conditions and management objectives will likely result in fluctuations in moose hunting opportunities over time. Support of hunting as a management strategy is beneficial since it
allows management agencies to manipulate moose density and distribution, whether it be to reduce moose density to manage for parasitism or to shift the population distribution to different parts of the state to mediate the relationship between moose foraging needs and forest regeneration needs.

Climate change is projected to have a range of environmental and social impacts in Maine (Fernandez et al., 2020) and nature-based tourism will not go unaffected. Changes in visitation patterns are likely to occur as weather events and conditions become more unpredictable and less favorable for certain outdoor activities (De Urioste-Stone et al. 2015, McCreary et al. 2019, Perry et al. 2018). Climate change planning related specifically to nature-based tourism will be essential in supporting communities that rely on this visitation. Participatory planning workshops provide an avenue for collaborative communication and planning related to tourism and climate change. This approach allows multiple stakeholders to establish shared concerns and priorities, and promotes community agency, which can benefit adaptation efforts (Chen, Xu, and Lew 2020). Establishing shared concerns and priorities between stakeholders and management agencies can greatly aid successful management by aligning public values and acceptance with management actions. Biophysical data about climate change impacts to the moose population can help outline science-based impacts and concerns, while social science data on stakeholder perceptions can aid in developing communication and outreach to target attitudes and support related to priorities.

Many actors including local residents, tourism suppliers, and management agencies will need to be involved to address the impending climate change impacts on Maine's intertwined social and ecological systems, including the complex moose socio-ecological system. A holistic understanding of these systems and their connections will be imperative in creating comprehensive solutions to the impacts derived from global changes, like climate change. Biophysical data is essential to outlining potential ecological impacts and determine objective risk, social science data contributes valuable information on how these impacts influence social systems and how humans will respond based on how they perceive the risk, and participatory planning and stakeholder engagement efforts build upon research findings to support collaborative adaptation development and implementation.
Moose hunting as a nature-based tourism activity will be directly influenced by moose management and moose population conditions that are influenced by climate change as this study shows. Tourism dependent communities can benefit from stakeholder driven solutions to changes in visitation that are related to changing climate and natural resource conditions; collaborative planning can help establish community capacity to withstand unpredictable levels of visitation. Chapter four explored participatory workshops as an approach to community-based planning for climate change in a nature-based tourism dependent community, and highlighted the value of collaborative planning efforts. Planning for climate change, in particular as it relates to changes in the relationship between moose and people in Maine, will benefit from locally relevant biophysical data and stakeholder perceptions to inform the identification of collective concerns and priorities related to current or potential changes. Stakeholders and communities reliant on moose could benefit from active community planning in order to establish plans for potential changes in moose hunting and moose viewing opportunities.

5.2 Future research

More research on the interconnected nature of social-ecological systems as they relate to climate change will benefit Maine’s ability to adapt to change. A better understanding of the ecological impacts of climate change on moose health, population dynamics, and landscape use will inform management and provide a better understanding of how climate change will influence moose hunting and people who rely on moose. Changes in moose landscape use also have the potential to impact the forest industry in Maine by changing patterns in moose browsing on regenerating forest stands, while concerns over moose health may inform forest practices; these moose socio-ecological system dynamics warrant further exploration. More research focused on the predictors of support for moose management would improve our understanding of how wildlife values and attitudes impact perceptions about the management agencies and the actions that they propose. Nature-based tourism reliant communities would benefit from more research on the effectiveness of, and how to improve, climate change planning and adaptation strategies. More research is required to better understand the best methods for engaging community members in planning efforts and creating long-term solutions for natural-resource dependent communities.
5.2 Transdisciplinary research and NRT

My Master's career at the University of Maine was shaped in part by my experiences as a trainee with the National Science Foundation National Research Trainee (NRT) Conservation Science program. As a trainee I was able to engage with multiple non-academic partners, take courses on transdisciplinary research, and in general think more broadly about what conservation means and the role of conservation science. This program was the catalyst for Chapter 4, which included collaboration with NRT partners and the application of multiple resilience and transdisciplinary principles learned in NRT courses. I was able to complete a required internship with the Appalachian Mountain Club, an NRT partner, where I developed my GIS skills and contributed to ongoing stream conservation efforts. The internship was one of the most valuable aspects of the program: it gave me applicable skills, provided an opportunity to be part of on the ground conservation, and collaborate with professionals in the fields of natural resource management and conservation.

The cohort of NRT trainees was an inspiring group of people; I learned so much from them and have a new appreciation for the value of collaboration and connection with peers. Connecting with the NRT Conservation Science partners was another highlight of the program. Connecting with and speaking to a diverse range of professionals in conservation has helped shape my future career goals and provided many resources. The connections that I developed with multiple NRT partners throughout the course of my time as an NRT trainee will stay with me long after I graduate. I am forever grateful for all of the opportunities to connect with colleagues, learn from NRT partners, and grow as a conservation professional.

5.3 Final thoughts

The results of this research can be leveraged to better understand and plan for changes in wildlife dynamics and human-wildlife relationships in Maine, specifically those of moose. This research contributes to our understanding of (1) moose winter habitat selection, (2) perceptions of moose and support of management, and (3) techniques for climate change planning in a nature-based tourism destination. The integration of interdisciplinary approaches to understand a complex social-ecological
system presented in this thesis outlines a framework for thinking about how climate change will impact wildlife, management entities, and individuals. This approach provides valuable insights into multiple dimensions of moose in Maine, their relationship with people, and considerations for planning for change.
REFERENCES


88


Miller, E., Van Megen, K., & Buys, L. (2012). Diversification for sustainable development in rural and regional Australia: How local community leaders conceptualise the impacts and opportunities from agriculture, tourism and mining. Rural Society, 22(1), 2-16.


Qualtrics software, Version 09/2020 of Qualtrics. Copyright © 2020 Qualtrics. Qualtrics and all other Qualtrics product or service names are registered trademarks or trademarks of Qualtrics, Provo, UT, USA. https://www.qualtrics.com


101


APPENDIX A: BIOPHYSICAL ANALYSIS SUPPLEMENTAL TABLES

Table A.1. Ten-year winter weather variable trends averaged between WMD 8 and WMD 2.

<table>
<thead>
<tr>
<th>Year</th>
<th>Precipitation$^1$</th>
<th>Snowfall$^1$</th>
<th>Maximum temperature$^1$</th>
<th>Minimum temperature$^1$</th>
<th>Snow Depth$^2$</th>
<th>Snow Density$^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>0.08</td>
<td>0.60</td>
<td>23.15</td>
<td>8.10</td>
<td>15.83</td>
<td>0.27</td>
</tr>
<tr>
<td>2011</td>
<td>0.12</td>
<td>0.90</td>
<td>21.61</td>
<td>4.20</td>
<td>18.61</td>
<td>0.26</td>
</tr>
<tr>
<td>2012</td>
<td>0.09</td>
<td>0.60</td>
<td>24.02</td>
<td>2.29</td>
<td>16.22</td>
<td>0.26</td>
</tr>
<tr>
<td>2013</td>
<td>0.10</td>
<td>0.88</td>
<td>22.08</td>
<td>1.91</td>
<td>15.05</td>
<td>0.32</td>
</tr>
<tr>
<td>2014</td>
<td>0.11</td>
<td>0.83</td>
<td>18.30</td>
<td>-1.67</td>
<td>21.34</td>
<td>0.22</td>
</tr>
<tr>
<td>2015</td>
<td>0.07</td>
<td>0.51</td>
<td>18.56</td>
<td>-2.42</td>
<td>17.85</td>
<td>0.26</td>
</tr>
<tr>
<td>2016</td>
<td>0.11</td>
<td>0.66</td>
<td>25.81</td>
<td>7.64</td>
<td>14.00</td>
<td>0.21</td>
</tr>
<tr>
<td>2017</td>
<td>0.10</td>
<td>0.86</td>
<td>22.87</td>
<td>1.22</td>
<td>21.52</td>
<td>0.23</td>
</tr>
<tr>
<td>2018</td>
<td>0.10</td>
<td>0.82</td>
<td>17.40</td>
<td>-5.06</td>
<td>19.60</td>
<td>0.19</td>
</tr>
<tr>
<td>2019</td>
<td>0.12</td>
<td>1.05</td>
<td>22.46</td>
<td>0.71</td>
<td>28.12</td>
<td>0.22</td>
</tr>
</tbody>
</table>

Note: Temperature units are in degrees Fahrenheit, all other units are in inches.

$^1$ NOAA Daily Summaries

$^2$ Maine Climate Snow Survey

Table A.2. Sample size and average home-range size per year for both WMD’s.

<table>
<thead>
<tr>
<th>Year</th>
<th>Sample size</th>
<th>Average home-range size (km$^2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>29</td>
<td>6.90</td>
</tr>
<tr>
<td>2</td>
<td>24</td>
<td>11.83</td>
</tr>
<tr>
<td>3</td>
<td>56</td>
<td>32.96</td>
</tr>
<tr>
<td>4</td>
<td>45</td>
<td>18.69</td>
</tr>
<tr>
<td>5</td>
<td>35</td>
<td>16.20</td>
</tr>
<tr>
<td>6</td>
<td>33</td>
<td>13.30</td>
</tr>
<tr>
<td>Total</td>
<td>222</td>
<td>28.34</td>
</tr>
</tbody>
</table>
APPENDIX B: SURVEY INSTRUMENT

Q1 PART A: In this section, we are interested in learning more about your perception of the current moose population in Maine and your personal experience with moose. Throughout the survey the following terms are referred to as:

Disease: a condition of the living animal body that impairs normal function and usually has specific signs and symptoms.
Parasite: an organism that lives on/in a host organism and gets food from or at the expense of the host.

Q2 How familiar are you with moose in Maine?

- Very familiar (1)
- Somewhat familiar (2)
- Neither familiar nor unfamiliar (3)
- Somewhat unfamiliar (4)
- Very unfamiliar (5)

Q3 Please indicate the extent to which you agree or disagree with the following statements:

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neither Agree nor Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
<th>Don't know</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maine's moose population is declining (1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moose encounters are becoming less common (2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maine's moose population is a good size (3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moose in Maine are healthy (4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maine has enough moose habitat to sustain its population (5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moose habitat is being lost due to human activity (7)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forestry practices in Maine create moose habitat (8)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moose avoid human encounters (9)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Q4 Have you ever been hunting for any game species in Maine?

- Yes (1)
- No (2)

Skip To: Q8 If Have you ever been hunting for any game species in Maine? = No

Q5 Have you ever received a moose hunting permit in Maine?

- Yes (1)
- No (2)

Skip To: Q8 If Have you ever received a moose hunting permit in Maine? = No

Q6 How many times have you been moose hunting in Maine?

- Once (1)
- 2-5 times (2)
- 6-10 times (3)
- More than 10 times (4)
- I have not been moose hunting in Maine (5)

Q7 Have you ever successfully harvested a moose in Maine?

- Yes (1)
- No (3)

Skip To: Q9 If Have you ever successfully harvested a moose in Maine? = Yes
Skip To: Q9 If Have you ever successfully harvested a moose in Maine? = No

Q8 Have you ever attempted to win a moose hunting permit in Maine?

- Yes (1)
- No (2)

Q9 Have you ever participated in a paid moose viewing activity (e.g. tours, safaris, etc)?

- Yes (1)
- No (2)

Skip To: Q11 If Have you ever participated in a paid moose viewing activity (e.g. tours, safaris, etc)? = No
**Q10 Have you ever seen a moose during a paid moose viewing activity (e.g. tours, safaris, etc)?**

- Yes (1)
- No (2)

**Q11 Have you ever benefited financially from moose? (e.g. guiding moose hunts or moose viewing tours, sale of moose hunting supplies, sale of moose apparel, memorabilia, or crafts, etc.)**

- Yes (1)
- No (2)

Skip To: Q13 If Have you ever benefited financially from moose? (e.g. guiding moose hunts or moose viewing tours,... = No

**Q12 How have you benefited financially from moose? (Select all that apply)**

- Moose hunt guiding (1)
- Moose viewing tour guiding (2)
- Sale of trinkets/clothing depicting moose (3)
- Sale of moose themed memorabilia and/or crafts (4)
- Sale of moose hunting supplies (7)
- Products and/or crafts made from moose antlers, hides, etc. from harvest moose (5)
- Other (Please specify:) (6) __________________________________________

**Q13 Please indicate the extent to which you agree or disagree with the following statements:**

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neither Agree nor Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>The primary value of moose is providing products useful to people (e.g. meat and hide) (1)</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>The primary value of moose is providing economic opportunity to communities (2)</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Moose are only valuable to Maine when providing economic benefits (3)</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>
Moose have value, whether people are present or not (4)

Moose have as much right to exist as people (5)

Wildlife, plants, and people have equal rights to live and develop (6)

Q14 PART B: In this section, we are interested in learning more about your perceptions of moose health and potential threats to moose in Maine.

Q15 In your opinion, how likely is it that the following things are taking place in Maine CURRENTLY?

<table>
<thead>
<tr>
<th></th>
<th>Extremely Likely</th>
<th>Likely</th>
<th>Neither Likely nor Unlikely</th>
<th>Unlikely</th>
<th>Extremely Unlikely</th>
</tr>
</thead>
<tbody>
<tr>
<td>The amount of moose habitat is declining (1)</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>The quality of moose habitat is declining (2)</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Diseases affecting moose are increasing (3)</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Parasites affecting moose are increasing (4)</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Winters are becoming less severe (5)</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Average annual temperatures are increasing (6)</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>
The white-tailed deer population is increasing (7)

Q16 On a scale of 1 to 10 (1=No risk at all, 10=A great deal of risk)

<table>
<thead>
<tr>
<th>How much risk do you believe the following factors pose to moose populations in Maine?</th>
<th>No risk at all to moose population health</th>
<th>A little risk to moose population health</th>
<th>A moderate amount of risk to moose population health</th>
<th>A lot of risk to moose population health</th>
<th>A great deal of risk to moose population health</th>
<th>Not Sure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Factor</td>
<td>Concern Level</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------------------------------------------------------------</td>
<td>---------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decreasing amount of habitat</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decreasing habitat quality</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increasing diseases in moose</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increasing parasites in moose</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decreasing winter severity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increasing average annual temperatures</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moose competing with white-tailed deer for food</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moose competing with other moose for food</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moose passing diseases to other moose</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Q17 How much concern do you have that the following factors are having a negative impact on moose in Maine CURRENTLY?**
Q18 In your opinion, what is the single most concerning factor that negatively impacts moose in Maine currently?

Q19 On a scale from 1 to 10 (1=No impact at all, 10=A great deal of impact)
How much do you believe that increases or decreases in Maine's moose population impact the following things?

<table>
<thead>
<tr>
<th>Extreme Concern</th>
<th>A lot of Concern</th>
<th>A moderate amount of Concern</th>
<th>A little Concern</th>
<th>No Concern at all</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increasing diseases in moose (1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increasing parasites in moose (2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increasing competition with white-tailed deer (3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increasing competition between moose (4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decreasing habitat (5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decreasing habitat quality (6)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moose-vehicle collisions (7)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forestry practices altering habitat (8)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decreasing food availability (9)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moose hunting (10)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increasing average annual temperatures (11)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Climate change (12)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Tourists coming to Maine ()

Maine's image as a tourism destination ()

Moose hunting opportunities ()

Maine traditions (customs/beliefs that are passed down through the generations) ()

Maine culture (characteristics, knowledge, arts, social institutions, and achievements) ()

Maine businesses ()

Your own day-to-day life ()

Maine's ecology ()

**Q20 Please indicate the extent to which you agree or disagree with the following statements:**

<table>
<thead>
<tr>
<th>Moose are a major tourism attraction for Maine (1)</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neither Agree nor Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moose are an important part of Maine's image and identity (2)</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Moose are an important economic contributor to Maine (3)</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Moose are an important food source for Maine residents (4)</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>People in Maine rely on moose for income (5)</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

**Q21 Please indicate the extent to which you agree or disagree with the following statements:**
<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neither Agree nor Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>There are too many people who want to hunt moose (1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>There are not enough moose to satisfy demand for hunting (2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moose hunting keeps moose populations healthy (3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moose hunting is a key part of managing moose populations (4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White-tailed deer hunting keeps moose populations healthy (5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moose hunting is part of Maine's economy (6)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moose hunting is part of Maine traditions (7)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moose hunting is an important part of Maine culture (8)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Q22 PART C: In this section, we are interested in learning more about how you feel about different moose management strategies.**

**Q23 Please indicate how comfortable or uncomfortable you are with the following moose management strategies:**

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Extremely Comfortable</th>
<th>Comfortable</th>
<th>Neither Comfortable nor Uncomfortable</th>
<th>Uncomfortable</th>
<th>Extremely Uncomfortable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increasing moose hunting to reduce population density and diseases/parasites in moose (1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Encouraging forestry companies to increase commercial forest harvesting to provide moose habitat (2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Increasing hunting of white-tailed deer to reduce competition and diseases/parasites in the moose population (3)

Encouraging landowners to increase forestry practices on their private land to provide moose habitat (4)

Q24 According to the Maine Department of Inland Fisheries and Wildlife, winter tick is a parasite that is negatively impacting moose health in Maine by lowering reproductive rates and increasing winter mortality of calves. Reducing moose numbers could break the tick cycle and reduce winter calf mortality. Increased cow moose harvest and fewer moose would mean a more productive and healthy moose population. Would you support an increase in cow moose hunting permits in order to reduce winter tick populations?

○ Definitely yes (16)
○ Probably yes (17)
○ Might or might not (18)
○ Probably not (19)
○ Definitely not (20)

Q25 Please indicate the extent to which the following statements are applicable to your own life and experiences:

<table>
<thead>
<tr>
<th>Statement</th>
<th>Extremely Applicable</th>
<th>Applicable</th>
<th>Neither Applicable nor Not Applicable</th>
<th>Not Applicable</th>
<th>Extremely Not Applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td>The people important to me support increased moose hunting (1)</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>
The people important to me support forestry companies increasing commercial forest harvesting to provide moose habitat (2)

The people important to me support increased hunting of white-tailed deer (3)

The people important to me support increased forestry practices by landowners on private land to provide moose habitat (4)

**Q26 Please indicate the extent to which the people important to you would approve or disapprove of you engaging in the following activities:**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Strongly Approve</th>
<th>Approve</th>
<th>Neither Approve nor Disapprove</th>
<th>Disapprove</th>
<th>Strongly Disapprove</th>
<th>N/A (Not able to engage in activity)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engaging in moose hunting to reduce population density and diseases/parasites in moose (1)</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>Signing a petition to encourage forestry companies to increase commercial forest harvesting to provide moose habitat (2)</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
</tbody>
</table>
Engaging in white-tailed deer hunting to reduce competition and diseases/parasites in the moose population (3)

Signing a petition to encourage landowners to increase forestry practices on their private land to provide moose habitat (4)

Establishing forestry practices on your private land to provide moose habitat (5)

Increasing forestry practices on your private land to provide moose habitat (6)

Q27 What impact do you believe the following management scenarios will have on the health of Maine moose populations?

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Strong Positive Impact</th>
<th>Positive Impact</th>
<th>Neither Positive nor Negative Impact</th>
<th>Negative Impact</th>
<th>Strong Negative Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase in moose hunting (1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increase in white-tailed deer hunting (3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increase in commercial forest harvesting by forestry companies to provide moose habitat (4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Increase in forest harvesting by landowners on their private land to provide moose habitat (5)

Establishing forestry practices on your private land to provide moose habitat (6)

Increasing forestry practices on your private land to provide moose habitat (7)

**Q28 If you had to vote today, how likely would you be to:**

<table>
<thead>
<tr>
<th>Vote to support an increase in moose hunting to reduce moose population density (1)</th>
<th>Extremely Likely</th>
<th>Likely</th>
<th>Neither Likely nor Unlikely</th>
<th>Unlikely</th>
<th>Extremely Unlikely</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Vote to support an increase in moose hunting to reduce diseases in moose (11)</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Vote to support an increase in moose hunting to reduce parasites in moose (10)</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Question</td>
<td>Likely</td>
<td>Neither</td>
<td>Unlikely</td>
<td>Extremely Likely</td>
<td>Extremely Unlikely</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>--------</td>
<td>---------</td>
<td>----------</td>
<td>------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>Vote to support an increase in white-tailed deer hunting to reduce competition with moose</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>Vote to support an increase in white-tailed deer hunting to reduce diseases in the moose population</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>Vote to support an increase in white-tailed deer hunting to reduce parasites in the moose population</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>Vote to reduce the amount of moose hunting permits</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>Vote to reduce the amount of white-tailed deer hunting permits</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
</tbody>
</table>

Q29 If you had to vote today, how likely would you be to:

- Vote to provide tax breaks to forestry companies who increase commercial forest harvesting to provide moose habitat (1)
- Vote to provide tax breaks to landowners who increase forestry practices on their private land to provide moose habitat (2)
- Vote to reduce the amount of forest harvesting in Maine (3)
- Other (Please specify): (4)

Q30 Are you personally planning on engaging in the following actions within the next 5 years?

- Advocate for forestry companies to increase commercial forest harvesting to provide moose habitat (2)
Advocate for landowners to increase forestry practices on their private land to provide moose habitat (5)

Establish forestry practices on your private land (4)

Increase forestry practices on your private land (9)

Hunt for moose (1)

Hunt for white-tailed deer (3)

Protest increased forest harvesting (6)

Protest increased moose hunting (7)

Protest increased white-tailed deer hunting (8)

Q31 The Maine Department of Inland Fisheries and Wildlife (MDIFW) is a state agency that preserves, protects, and enhances the inland fisheries and wildlife resources of Maine and is also responsible for promoting the safe enjoyment of Maine's outdoors and Wildlife.

For the following series of statements about the Maine Department of Inland Fisheries and Wildlife (MDIFW), please indicate the extent to which you agree or disagree:
<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neither Agree nor Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>The MDIFW provides the best available information on moose population health in Maine (1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The MDIFW provides the best available information on threats to the moose population in Maine (6)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The MDIFW provides the best available information on the impacts of wildlife management on the moose population in Maine (7)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The MDIFW provides information on moose in Maine in a timely manner (2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The MDIFW typically makes good decisions regarding moose management (3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The MDIFW properly addresses moose health issues in Maine (4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The MDIFW sets the right amount of yearly moose hunting permits (5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q32 Do you feel up to date on information regarding current moose population health and management?

- Definitely yes (1)
- Probably yes (2)
- Might or might not (3)
- Probably not (4)
- Definitely not (5)

Q33 How do you receive information about moose health in Maine? (Please check all that apply)

- Reading about moose health on the Maine Department of Inland Fisheries & Wildlife website (1)
- Reading about moose health in an online document from another internet website (2)
- Reading about moose health in a print document from the Maine Department of Inland Fisheries & Wildlife (3)
- Reading about moose health on a social media website (Facebook, Twitter, etc.) (4)
- Discussing moose health with friends (5)
Discussing moose health with family members (6)
Reading about moose health in magazines or books (7)
Reading about moose health in a hunting/ sportsman's club newsletter (8)
Learning about moose health from conservation groups (9)
Attending live presentations about moose health (10)
Listening to radio news/ radio programs on moose health (11)
Other (please specify): ________________________________

Q34 What would be your ideal way to learn about MOOSE HEALTH from the Maine Department of Inland Fisheries & Wildlife? (Please check all that apply)
Maine Department of Inland Fisheries & Wildlife website (1)
Print documents (Newsletters, etc.) (2)
Social media (Facebook, Twitter, etc.) (3)
Magazine/ Newspaper articles (4)
Live presentations (5)
Radio programs (6)
Other (please specify): ________________________________

Q35 What would be your ideal way to learn about MOOSE MANAGEMENT from the Maine Department of Inland Fisheries & Wildlife? (Please check all that apply)
Maine Department of Inland Fisheries & Wildlife website (1)
Print documents (Newsletters, etc.) (2)
Social media (Facebook, Twitter, etc.) (3)
Magazine/ Newspaper articles (4)
Live presentations (5)
Q36 Part D: This final section of the survey will give us some background information on you.

Q37 What state do you live in? _______________________

Q38 What is your Zip code? _________________

Q39 What is your occupation? ______________________

Q40 What is your age? _______________________

Q41 What is your gender?

- Male (1)
- Female (2)
- Non-binary (3)

Q42 What is the highest level of education you have completed?

- Primary or some high school (1)
- High school graduate (2)
- Some college (3)
- 2 year degree (4)
- 4 year degree (5)
- Graduate degree (8)
- Professional degree (6)

Q43 What is your political ideology?

- Liberal (1)
- Conservative (2)
- Moderate (3)
- Undecided (4)

Q44 What is your combined household income?

- Less than $10,000 (1)
- $10,000 - $19,999 (2)
$20,000 - $29,999  (3)
$30,000 - $39,999  (4)
$40,000 - $49,999  (5)
$50,000 - $59,999  (6)
$60,000 - $69,999  (7)
$70,000 - $79,999  (8)
$80,000 - $89,999  (9)
$90,000 - $99,999  (10)
$100,000 - $149,999  (11)
More than $150,000  (12)

Q45 Which race/ethnicity do you identify with? (Please check all that apply)

☐ American Indian or Alaska Native  (3)
☐ Asian  (4)
☐ Black or African American  (2)
☐ Native Hawaiian or Pacific Islander  (5)
☐ White (Hispanic/Latinx)  (1)
☐ White (non-Hispanic/Latinx)  (7)
☐ Other (Please specify):  (6) ______________________________________

Q60 How did you receive your invitation to take this survey?

☐ Email  (1)
☐ Mailed letter  (2)
Dear Mr(s),

You are invited to participate in a research project being conducted by Asha DiMatteo-LePape, a graduate student, and Dr. Sandra De Urioste-Stone, a faculty member, both in the School of Forest Resources at the University of Maine. The goal of this project is to learn more about perceptions of moose in Maine including moose management, moose population health, and risk perceptions of moose and climate change.

We obtained your contact information through InfoUSA. As a Maine resident we would greatly appreciate if you would be willing to share your views. The anonymous survey should only take about 20 minutes to complete and you must be 18+ years old to participate. To learn more about this study and to take the survey please go to the link below:

(Link)

You will receive up to two reminders encouraging you to complete this survey, you have until October 15th to complete it. Your help is very much appreciated.

Respectfully yours,

Asha DiMatteo-LePape  
M.S. Student  
School of Forest Resources  
asha.dimatteolepape@maine.edu  
Tel (802) 380-1245
APPENDIX D: EMAILED RECRUITMENT SCRIPT FOR SURVEY

Dear Mr(s),

My name is Asha DiMatteo-LePape, and I am a graduate student in the School of Forest Resources at the University of Maine. I am working with Dr. Sandra De Urioste-Stone, a professor of nature-based tourism at the University of Maine, Orono. I am currently conducting a study to learn about perceptions of moose in Maine including moose management, moose population health, and risk perceptions of moose and climate change.

We received your contact information from Maine Department of Inland Fisheries and Wildlife moose permit records. As a moose hunter in Maine we would greatly appreciate if you would be willing to share your views. The anonymous survey should only take about 20 minutes to complete and you must be 18+ years old to participate. To learn more about this study and to take the survey please go to the link below:

(Link)

You will receive up to two reminders encouraging you to complete this survey, you have until October 15th to complete it.

Respectfully yours,

Asha DiMatteo-LePape
M.S. Student
School of Forest Resources
asha.dimatteolepape@maine.edu
Tel (802) 380-1245
Dear Mr(s),

Recently, we sent you an invitation to participate in our important study about moose in Maine. To our knowledge, we have not yet received your responses. We would like to urge you to share your views regarding moose and moose management by completing the questionnaire. Your address is one of only a small number that have been randomly selected to help in this study. To respond to the survey, simply go to the following website:

(Survey Link)

Upon completion of the survey you may enter to win one of two $25 L.L.Bean gift cards. Thank you for your help.

Asha DiMatteo-LePape
M.S. Student
School of Forest Resources
asha.dimatteolepape@maine.edu
Tel (802) 380-1245
APPENDIX F: SURVEY 2nd REMINDER

Dear Mr(s),

We still need your help! Recently, we sent you an invitation to participate in our important study about moose and moose management in Maine. Your views matter greatly to us and are key to the success of this project. Since you cannot be replaced, we wanted to offer you one last opportunity before we close the survey. Your participation is voluntary and your responses will be anonymous. Please enter the survey link below into your search browser:

(Survey Link)

Upon completion of the survey you may enter to win one of two $25 L.L.Bean gift cards. Thank you for your help with this important project!

Asha DiMatteo-LePape  
M.S. Student  
School of Forest Resources  
asha.dimatteolepape@maine.edu  
Tel (802) 380-1245
APPENDIX G: SURVEY INFORMED CONSENT

You are invited to participate in a research project being conducted by Asha DiMatteo-LePape, a graduate student in the Department of Forest Resources at the University of Maine, and faculty sponsor Dr. Sandra De Urioste-Stone in the School of Forest Resources. The purpose of the research is to learn more about perceptions of moose in Maine including moose management, moose population health, and risk perceptions of moose and climate change. You must be at least 18 years of age to participate.

What Will You Be Asked to Do?
You will be asked to participate in a survey that will last about 20 minutes. You have until October 15th to complete the survey.

Sample questions:
1. Have you ever participated in a moose viewing tour?
2. To what degree do you believe that changes in the moose population impact Maine traditions?

Risks
Except for your time and inconvenience, there are no risks to you from participating in this study.

Benefits
While this study will have no direct benefit to you, this research may help us learn more about perceptions of moose management in Maine and potentially aid in future moose management in the state.

Compensation
Upon reaching the end of the survey, you will have the opportunity to enter your name into a raffle for one of two $25 LL Bean gift cards which will be emailed to the winners.

Confidentiality
Your responses for this survey will be anonymous. Please do not type your name anywhere on the questionnaire. The survey data will be stored on a secure electronic database. The Qualtrics database will be maintained until August 1st 2021, aggregate data will be kept indefinitely on a password protected computer.

Voluntary
Participation is voluntary. You may stop at any time or skip questions, but you must reach the end of the survey to enter the raffle. Submitting the survey implies consent to participate.

Contact Information
If you have any questions about this study, please contact me at 802/380-1245, or email asha.dimatteolepape@maine.edu. You may also reach the faculty advisor on this study at 207/581-2885, or email sandra.de@maine.edu. If you have any questions about your rights as a research participant, please contact the Office of Research Compliance, University of Maine, 207/581-2657 (or e-mail umric@maine.edu).
A socio-ecological approach to assess moose habitat ecology and perceptions of management in Maine

1. Summary:

Moose are an iconic wildlife species in the state of Maine that contribute to recreation, tourism, and the identity of people in the state (LaBarbera, 2002). Climate change has increased temperatures in Maine: winters are becoming milder and spring is arriving sooner than usual (Fernandez et al., 2020; Rustad et al., 2012). These fluctuations in seasonality have implications for changes in forest composition and environmental conditions that influence moose spatial and temporal distributions (Ma et al., 2020; Rempel, 2011; Weiskopf et al., 2019). To determine the scope of impact that changing seasonality will have on moose habitat selection, population dynamics, as well as the social, economic, and cultural relationship that people in Maine have with moose, a transdisciplinary research approach will be implemented. In order to understand the risk perceptions associated with moose population health in Maine, and the effects that perceptions might have on decisions to support specific moose management actions, a survey will be administered to two groups: moose hunters, who interact directly with moose, and Maine residents who may have different perceptions and values for moose. Understanding the value that people have for moose and the concerns that they have about the future of Maine’s moose population will help inform management objectives, and provide insight into how changes in the determined habitat selection factors could influence the relationship between people and moose in Maine.

Methods

An online anonymous survey will be used to explore perceptions of moose and moose
management (20 minute). The target participants will be either moose hunters or Maine residents. The survey instrument will be created and administered using Qualtrics. In order to reduce measurement error and participant exhaustion, the survey instrument will be carefully drafted and modified, and the questionnaire will be pre-tested prior to implementation (Dillman, Smyth, & Christian, 2014; Visser, Krosnick, & Lavrakas, 2000). Survey data will be analyzed using SPSS. The survey will be administered during summer 2020; the survey will remain open until October 15, 2020. Data will be downloaded and saved in a password protected computer, located in the locked office of the principal investigator. To increase response rate, participants will receive up to two reminders.

References


2. Personnel:

PI: Asha DiMatteo-LePape, Graduate student

Ms. DiMatteo-LePape is a M.S. student in the School of Forest Resources. She has completed the human subjects training through the UMaine IRB and has prior human subjects' research experience through the completion of an undergraduate honors thesis on risk perceptions of moose-winter tick interactions in Maine.

Sponsor: Dr. Sandra De Urioste-Stone, Associate Professor of Nature-based Tourism, School of Forest Resources, University of Maine, Orono, Maine, USA. Dr. De Urioste-Stone is an applied social scientist who has conducted over 20 projects involving human subjects. She has extensive experience conducting social science surveys, implementing an array of qualitative research studies, and participating in interdisciplinary research projects in the US and abroad. While at the University of Idaho, she cooperated with the National Park Service to implement and interpret data collected from visitors to US National Parks. Dr. De Urioste-Stone has completed the human subjects training through the UMaine IRB.

Faculty mentor: Dr. John Daigle, Professor of Forest Recreation Management, School of Forest Resources, University of Maine, Orono, Maine, USA. Dr. Daigle has over 30 years of experience
working with human subjects. He has conducted a number of visitor surveys while at the University of Maine including the St. Croix International Waterway, Acadia National Park, Allagash Wilderness Waterway, Maine Coastal Islands Trail, and Baxter State Park. Dr. Daigle is currently certified through the University of Maine to work with human subjects and has completed human subjects training through the UMaine IRB.

3. Participant recruitment:

All participants will be adults (18 years of age or older) of undiminished autonomy, capable of making a truly voluntary decision whether or not to participate. The population targeted in this study includes Maine residents as well as moose hunters. We plan to send invitations to a sample of 3,000 potential participants, and expect a 20% response rate. The proposed number of participants was calculated by determining the necessary number of responses for accurate data analysis. Participants will be identified in two ways: moose hunters will be identified using the (1) Maine Department of Inland Fisheries and Wildlife moose hunting permit list, and (2) Maine residents will be identified through a purchased random sample of potential participants from InfoUSA. Potential participant lists will be cross-checked so that there is no overlap between the moose hunter and Maine resident samples; if an overlap occurs the potential participant will be counted as a moose hunter. Participants will be recruited by a mailed (Maine residents) recruitment letter (Appendix A) or an emailed (moose hunters) recruitment letter (Appendix B) inviting them to complete the online survey (Appendix F) via an included link. An initial follow-up reminder (Appendix D) will be sent to Maine residents using a postcard and moose hunters using email on September 1st. A final reminder (Appendix E) to be sent on October 1st will be sent to Maine residents using a postcard and moose hunters using email.
4. Informed consent:

Consent will be implied by submission of the questionnaire. A consent form (Appendix C) will be included at the beginning of the self-administered online survey instrument. The consent forms will be accessed through the recruitment letters and will link participants directly to the self-administered online survey instrument.

5. Confidentiality:

The following precautions will be addressed to ensure privacy of participants and confidentiality of data:

Online survey data will be collected using Qualtrics; no IP addresses will be collected. Data will be downloaded off Qualtrics to the principal investigator’s computer and shared with the faculty sponsor and committee member Dr. John Daigle for analysis. All data will be stored on password protected computers. Data will be deleted off of Qualtrics after one year (August 1st, 2021) and kept indefinitely on a password protected computer. The survey will be anonymous for participants as no names will be linked to the data. Names and contact information entered after the completion of the questionnaire as part of the raffle will not be associated with the survey responses.

6. Risks to participants:

The potential risks to participants may include time investment and inconvenience of completing the questionnaire.

7. Benefits:

Individuals participating in the online survey will not gain any direct benefit from participating in the study. The overall potential benefit of the research includes:
● In-depth studying of risk perceptions related to moose (Alces alces) health, and moose management can help inform wildlife management decisions by government agencies.

● Increased understanding of Maine resident and moose hunter values for moose in Maine and behavioral intentions to support different moose management strategies.

● Provide information useful to decision makers to improve the understanding of how risk perceptions influence attitudes and behaviors associated with moose management in the State.

8. Compensation:

Compensation for completing the questionnaire will be the opportunity to enter a raffle to win one of two $25 LL Bean gift cards which will be emailed to the winners. In order to be eligible to enter the raffle participants must reach the end of the online survey. The text that appears as part of the raffle entry page is as follows:

“Thank you for participating in this survey! Enter your contact information below to enter a raffle for the chance to win one of two $25 LL Bean gift cards. Your contact information is not linked to your survey responses.

Name: Email: ”
APPENDIX I: SURVEY ANALYSIS SUPPLEMENTAL TABLES

Table I.1 Sociodemographics for the full sample and by group

<table>
<thead>
<tr>
<th>Variable</th>
<th>Full Sample (%)</th>
<th>Moose Hunter (%)</th>
<th>Non-moose Hunter (%)</th>
<th>Non-hunter (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>74.9</td>
<td>86.5</td>
<td>84.0</td>
<td>41.4</td>
</tr>
<tr>
<td>Female</td>
<td>25.1</td>
<td>13.5</td>
<td>16.0</td>
<td>58.6</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18-24</td>
<td>2.6</td>
<td>2.0</td>
<td>4.4</td>
<td>2.3</td>
</tr>
<tr>
<td>25-39</td>
<td>12.6</td>
<td>16.0</td>
<td>8.8</td>
<td>8.5</td>
</tr>
<tr>
<td>40-59</td>
<td>36.3</td>
<td>39.6</td>
<td>33.9</td>
<td>31.1</td>
</tr>
<tr>
<td>60+</td>
<td>48.5</td>
<td>42.4</td>
<td>52.9</td>
<td>58.1</td>
</tr>
<tr>
<td>Level of education</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary or some high school</td>
<td>1.0</td>
<td>1.2</td>
<td>0.9</td>
<td>0.8</td>
</tr>
<tr>
<td>High school graduate</td>
<td>18.4</td>
<td>18.8</td>
<td>27.6</td>
<td>9.5</td>
</tr>
<tr>
<td>Some college</td>
<td>20.2</td>
<td>20.0</td>
<td>22.8</td>
<td>18.3</td>
</tr>
<tr>
<td>2 year, 4 year, or professional degree</td>
<td>48.1</td>
<td>50.2</td>
<td>40.1</td>
<td>50.8</td>
</tr>
<tr>
<td>Graduate degree</td>
<td>12.3</td>
<td>9.8</td>
<td>8.6</td>
<td>20.6</td>
</tr>
<tr>
<td>Annual household income</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than $10,000</td>
<td>1.0</td>
<td>0.9</td>
<td>1.9</td>
<td>0.4</td>
</tr>
<tr>
<td>$10,000-$49,000</td>
<td>19.3</td>
<td>16.2</td>
<td>20.7</td>
<td>25.4</td>
</tr>
<tr>
<td>$50,000-$99,000</td>
<td>41.4</td>
<td>42.6</td>
<td>40.9</td>
<td>39.3</td>
</tr>
<tr>
<td>$100,000-$149,000</td>
<td>22.0</td>
<td>22.8</td>
<td>24.5</td>
<td>17.9</td>
</tr>
<tr>
<td>More than $150,000</td>
<td>16.3</td>
<td>17.5</td>
<td>12.0</td>
<td>17.0</td>
</tr>
<tr>
<td>Political ideology</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liberal</td>
<td>8.8</td>
<td>3.3</td>
<td>5.3</td>
<td>25.0</td>
</tr>
<tr>
<td>Moderate</td>
<td>19.8</td>
<td>17.2</td>
<td>21.2</td>
<td>24.7</td>
</tr>
<tr>
<td>Conservative</td>
<td>36.7</td>
<td>40.9</td>
<td>42.8</td>
<td>21.4</td>
</tr>
</tbody>
</table>
Table I.1 continued

<table>
<thead>
<tr>
<th>Undecided</th>
<th>34.7</th>
<th>38.6</th>
<th>30.7</th>
<th>28.9</th>
</tr>
</thead>
</table>

Table I.2 Sample sociodemographics and means per group

<table>
<thead>
<tr>
<th>Variable</th>
<th>Sample Mean (N)</th>
<th>Moose Hunter (N)</th>
<th>Non-moose Hunter (N)</th>
<th>Non-hunter (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender¹</td>
<td>1.25 (1066)</td>
<td>1.13 (572)</td>
<td>1.16 (231)</td>
<td>1.59 (263)</td>
</tr>
<tr>
<td>Age²</td>
<td>57 (1051)</td>
<td>55 (564)</td>
<td>57 (227)</td>
<td>60 (260)</td>
</tr>
<tr>
<td>Level of education³</td>
<td>4.25 (1068)</td>
<td>4.17 (574)</td>
<td>3.77 (232)</td>
<td>4.86 (262)</td>
</tr>
<tr>
<td>Annual household income⁴</td>
<td>8.43 (963)</td>
<td>8.69 (531)</td>
<td>8.16 (208)</td>
<td>8.05 (224)</td>
</tr>
<tr>
<td>Political ideology⁵</td>
<td>2.43 (852)</td>
<td>2.61 (450)</td>
<td>2.54 (183)</td>
<td>1.95 (219)</td>
</tr>
</tbody>
</table>

¹ Measured on a categorical scale of 1 = male, 2 = female, 3 = non-binary
² Measure of reported age in years
³ Measured on an ordinal scale of 1 = primary or some high school to 8 = graduate degree
⁴ Measured on an ordinal scale of 1 = less than $10,000 to 12 = more than $150,000
⁵ Measured on a categorical scale of 1 = liberal, 2 = moderate, 3 = conservative
APPENDIX J: SUPPLEMENTAL SURVEY ANALYSIS

Given the amount of information collected in the survey, this appendix shares some additional results not discussed as part of this thesis. These include percentages of respondents likely and unlikely to support increasing moose hunting permits after being presented with ecological information about winter tick and moose dynamics (Table J.1), perceived familiarity and knowledge of moose by Maine moose hunters and out-of-state moose hunters (Table J.2), and percent of moose hunter respondents likely to support an increased moose hunting management strategy based on justification (Table J.3).

Table J.1. Reported support for increasing moose hunting permits for female (cow) moose in order to address winter tick infestation in the Maine moose population after receiving background information on winter tick and moose density dynamics.

<table>
<thead>
<tr>
<th>Support increasing cow moose permits to combat winter</th>
<th>Percent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definitely yes</td>
<td>22.7</td>
</tr>
<tr>
<td>Probably yes</td>
<td>36.2</td>
</tr>
<tr>
<td>Might or might not</td>
<td>21.0</td>
</tr>
<tr>
<td>Probably not</td>
<td>13.2</td>
</tr>
<tr>
<td>Definitely not</td>
<td>7.0</td>
</tr>
</tbody>
</table>

Table J.2. Perceived familiarity and knowledge of the moose population in Maine by Maine moose hunters and out-of-state moose hunters.

<table>
<thead>
<tr>
<th>Percent of respondents:</th>
<th>Maine Moose hunters</th>
<th>Out of state moose hunters</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very familiar with moose in Maine</td>
<td>48</td>
<td>20</td>
<td>44</td>
</tr>
<tr>
<td>Reporting definitely up to date on moose health and management information</td>
<td>19</td>
<td>21</td>
<td>20</td>
</tr>
<tr>
<td>Reporting probably up to date on moose health and management information</td>
<td>46</td>
<td>53</td>
<td>67</td>
</tr>
</tbody>
</table>
Table J.3. Percent of moose hunter respondents likely to support an increased moose hunting management strategy based on justification.

<table>
<thead>
<tr>
<th>Justification for increased moose hunting management strategy</th>
<th>Percent likely to extremely likely to support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduce moose population density</td>
<td>49</td>
</tr>
<tr>
<td>Reduce diseases in moose</td>
<td>62</td>
</tr>
<tr>
<td>Reduce parasites in moose</td>
<td>63</td>
</tr>
</tbody>
</table>

Additional analysis consisted of the creation of indices (Table J.4, Table J.5) and a confirmatory factor analysis (CFA) for further exploration of moose hunter values, perceptions, attitudes, norms, and behavior intentions. CFA resulted in good model fit (CFI=.968, TLI=.953, RMSEA=.050) and high factor loadings for all latent variables.

Table J.4. Indices and internal consistency

<table>
<thead>
<tr>
<th>Index</th>
<th>Mean</th>
<th>SD</th>
<th>Cronbach’s α</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parasite Risk Perception</td>
<td>3.62</td>
<td>1.00</td>
<td>0.68</td>
</tr>
<tr>
<td>Moose General Value</td>
<td>3.85</td>
<td>0.58</td>
<td>0.75</td>
</tr>
<tr>
<td>Moose Hunting Value</td>
<td>4.27</td>
<td>0.68</td>
<td>0.86</td>
</tr>
<tr>
<td>Confidence in Agency</td>
<td>3.76</td>
<td>0.85</td>
<td>0.89</td>
</tr>
<tr>
<td>Moose Hunting Strategy Norms</td>
<td>3.20</td>
<td>1.10</td>
<td>0.72</td>
</tr>
<tr>
<td>Moose Hunting Strategy Attitude</td>
<td>3.45</td>
<td>0.89</td>
<td>0.75</td>
</tr>
<tr>
<td>Moose Hunting Strategy Voting Intention</td>
<td>3.48</td>
<td>1.07</td>
<td>0.95</td>
</tr>
</tbody>
</table>

Table J.5. Index intercorrelations

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>N=647</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Parasite Risk Perception</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Moose General Value</td>
<td>0.253**</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Moose Hunting Value</td>
<td>0.125**</td>
<td>0.564**</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Confidence in Agency</td>
<td>0.064</td>
<td>0.036</td>
<td>0.137**</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table J.5 continued

<table>
<thead>
<tr>
<th></th>
<th>Value 1</th>
<th>Value 2</th>
<th>Value 3</th>
<th>Value 4</th>
<th>Value 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. Moose Hunting Strategy Norms</td>
<td>-0.042</td>
<td>0.099*</td>
<td>0.236**</td>
<td>0.344**</td>
<td>1.00</td>
</tr>
<tr>
<td>6. Moose Hunting Strategy Attitude</td>
<td>-0.032</td>
<td>0.032</td>
<td>0.189**</td>
<td>0.424**</td>
<td>0.665**</td>
</tr>
<tr>
<td>7. Moose Hunting Strategy Voting Intention</td>
<td>0.011</td>
<td>0.074</td>
<td>0.171**</td>
<td>0.396**</td>
<td>0.681**</td>
</tr>
</tbody>
</table>
## APPENDIX K: WORKSHOP RESULTS SUPPLEMENTAL TABLE

Table K.1. Participant list of climate change impacts and opportunities for tourism on MDI.

<table>
<thead>
<tr>
<th>Category</th>
<th>Impacts and Opportunities Generated by Workshop Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increasing heat and temperatures</td>
<td>Increasing average annual temperature</td>
</tr>
<tr>
<td></td>
<td>Increasing number of high heat index days</td>
</tr>
<tr>
<td></td>
<td>Increasing frequency of droughts; drier summers</td>
</tr>
<tr>
<td></td>
<td>Higher fire risk in summer</td>
</tr>
<tr>
<td></td>
<td>Changes in visitor travel behavior due to increased heat</td>
</tr>
<tr>
<td></td>
<td>Changes in water management and use</td>
</tr>
<tr>
<td></td>
<td>Warming oceans impact the lobster fishing industry</td>
</tr>
<tr>
<td></td>
<td>Increasing hazardous air quality days</td>
</tr>
<tr>
<td>Changes to precipitation and water resources</td>
<td>Increasing average annual rainfall</td>
</tr>
<tr>
<td></td>
<td>Decreasing average annual snowpack</td>
</tr>
<tr>
<td></td>
<td>Changes in average annual ice storms</td>
</tr>
<tr>
<td></td>
<td>Different patterns of winter outdoor recreation</td>
</tr>
<tr>
<td></td>
<td>More winter storms</td>
</tr>
<tr>
<td></td>
<td>Changes in frequency of flooding events</td>
</tr>
<tr>
<td></td>
<td>Winter flooding from changing snow and rain patterns</td>
</tr>
<tr>
<td></td>
<td>Erosion</td>
</tr>
<tr>
<td></td>
<td>Competing water management priorities</td>
</tr>
<tr>
<td>Changes to flora and fauna</td>
<td>Changes in tick population (e.g., increases and shifting species)</td>
</tr>
<tr>
<td></td>
<td>Changes in mosquito population</td>
</tr>
<tr>
<td></td>
<td>Changes in abundance of wildlife</td>
</tr>
<tr>
<td></td>
<td>Decreasing abundance of native plants</td>
</tr>
<tr>
<td></td>
<td>Increasing abundance of invasive species</td>
</tr>
<tr>
<td></td>
<td>Changes in pests and pathogens</td>
</tr>
<tr>
<td></td>
<td>More frequent algal blooms</td>
</tr>
<tr>
<td>Unpredictability of impacts</td>
<td>Increasing frequency and intensity extreme weather events (e.g., extreme rainfall, storm surges, etc.)</td>
</tr>
<tr>
<td></td>
<td>Increasing infrastructure damage from natural events</td>
</tr>
<tr>
<td></td>
<td>Increasing risk of natural disasters</td>
</tr>
</tbody>
</table>
| Changes in visitation | Increasing visitation (i.e., extended season)  
Increasing visitation can impact vegetation and wildlife  
Opportunity for visitation and longer seasons to provide more year round economic stability for tourism suppliers  
Opportunity to spread out visitation across seasons to reduce crowding and increase tourism supplier income stability  
Increasing soil erosion from trampling and visitors going off trails |
| Climate change impacts on management and human well-being | Changes in staffing requirements  
Competing demand for housing by residents and visitors  
Infrastructure not adapted for year-round use  
Weather-related accidents for residents and visitors  
Opportunity to model sustainability in the tourism destination  
Opportunity to learn from and connect with stakeholders in other tourism destinations that are addressing climate change |
BIOGRAPHY OF THE AUTHOR

Asha DiMatteo-LePape was born in Leyden, Massachusetts on August 20, 1997. She grew up playing in the woods in rural Vermont. After four years and a semester abroad in Ecuador, she graduated from Brattleboro Union High School in 2015. Asha attended the University of Maine, where she graduated with a Bachelor’s degree with double majors in Parks, Recreation, & Tourism and Ecology & Environmental Science with concentrations in Nature Based Tourism and Sustainability, Environmental Policy, & Natural Resource Management respectively. She spent all four years of her undergraduate career at UMaine working for the Maine Bound Outdoor Adventure Center introducing students to the beautiful Maine landscape through outdoor adventure. She returned to the University of Maine to study conservation science as a National Science Foundation National Research Trainee. She entered the graduate program in the School of Forest Resources in the fall of 2019 and worked as a Graduate Assistant for the Outdoor Leadership program in the School of Kinesiology, Physical Education, and Athletic Training. After receiving her degree, Asha will be pursuing a career in ecology, landscape conservation, and community engagement. Asha is a candidate for the Master of Science degree in Forest Resources from the University of Maine in August 2021.