

Spring 2019

# A Qualitative Study of the Perceived Risks of the Impacts of Moose-Winter Tick Interactions on Human Health, Maine Economy, and Maine Culture

Asha DiMatteo-LePape

Follow this and additional works at: <https://digitalcommons.library.umaine.edu/honors>

 Part of the [Ecology and Evolutionary Biology Commons](#), and the [Recreation, Parks and Tourism Administration Commons](#)

A QUALITATIVE STUDY OF THE PERCEIVED RISKS OF THE IMPACTS OF  
MOOSE-WINTER TICK INTERACTIONS ON HUMAN HEALTH, MAINE  
ECONOMY, AND MAINE CULTURE

by

Asha DiMatteo-LePape

A Thesis Submitted in Partial Fulfillment  
of the Requirements for a Degree with Honors  
(Ecology and Environmental Science; Parks, Recreation, and Tourism)

The Honors College

University of Maine

May 2019

Advisory Committee:

Sandra De Urioste-Stone, Assistant Professor of Nature-based Tourism, Advisor  
Cristina Arrigoni Martelli, Assistant Professor of History  
John Daigle, Professor of Forest Recreation Management  
Adam Daigneault, Assistant Professor of Forest, Conservation, and Recreation  
Policy  
Darren Ranco, Associate Professor of Anthropology, Coordinator of Native  
American Research

## ABSTRACT

In order to answer the question of how people perceive the interactions between winter ticks and moose, and the impacts that these interactions may have on culture, economy, and recreational practices in Maine, interviews were conducted with participants from four stakeholder groups: hunters, outfitters, Wabanaki citizens, and wildlife managers. By using a case study methodology, I was able to explore moose health risk perceptions as described by participants from the four stakeholder groups, and the likely impacts on recreation behavior, livelihoods and economic viability, cultural maintenance, and wildlife management. In this study, multiple data generation techniques (i.e., semi-structured interviews, archival evidence, open ended responses from a questionnaire) were used to gain a deeper understanding of the phenomenon. Interviewees were identified using snowball sampling and searching the internet. Interview transcripts were analyzed using qualitative data analysis techniques in NVivo 12 Plus to gain an insight into how these stakeholders viewed the wildlife disease risk associated with winter ticks and moose, as well as how winter tick-moose interactions could impact economic vitality, recreation opportunities, cultural identity, and human health in Maine. While there seemed to be a high level of awareness among participants about ticks in general and the threat of Lyme disease, less was known about winter ticks as a separate species. It became clear that participants knew winter ticks could negatively impact moose, and that moose play a huge role in Maine culture. Hunting and recreational opportunities, cultural identity, and tourism all depend in part on having a healthy moose population. From outfitters leading moose viewing tours to Wabanaki citizens who rely on moose for sustenance, winter ticks are a threat. These perceptions

that winter ticks could be having direct negative impacts on moose health and indirect impacts on sociocultural and economic factors in Maine, stress the need for continued research on the biological impacts of winter ticks on moose, and more importantly, how these impacts could affect individuals, communities, businesses, and ecosystems in Maine.

## ACKNOWLEDGEMENTS

I would like to thank the UMaine Honors College and the School of Forest Resources for providing me with the opportunity to challenge myself to reach my full potential as an undergraduate. I would like to acknowledge the University of Maine Interdisciplinary Undergraduate Research Collaboratives which supplied the grant that funded this research. I want to thank my advisor, Dr. De Urioste-Stone, for all of her guidance, expertise, and inspiration throughout my thesis process. I would also like to thank Dr. Arrigoni Martelli for always pushing me to improve, and for introducing me to the fascinating field of environmental history. Thank you also to Jimmy Elliot for supporting this project and for being a wealth of knowledge and resources. Finally, I'd like to thank my committee for members for taking the time to be part of this project.

## TABLE OF CONTENTS

Abstract.....	ii
Acknowledgements.....	iv
Chapter 1: INTRODUCTION.....	1
Background.....	1
Justification/Significance.....	2
Study Purpose.....	5
Organization of Thesis.....	5
Chapter 2: DEFINING THE CASE.....	6
Maine Demographics, Culture, and Economics.....	6
Significance of Moose to Wabanaki Culture.....	7
Significance of Moose to Maine.....	8
Historical and Current Moose Status and Disease.....	9
Chapter 3: METHODOLOGICAL APPROACH.....	11
Researcher’s Role-Researcher as Instrument.....	12
Research Methodology.....	13
Ethics.....	15
Defining the Stakeholder Groups.....	16
Selecting the Participants.....	17
Data Generation Methods.....	18
Review of Archival Evidence.....	19
Semi-structured Interviews.....	23

Open-ended Questionnaire Responses.....	26
Reflective Journal.....	26
Usefulness of the Data Generation Methods Used.....	27
Organization of Data, Database Creation, Data Entry and Management.....	29
Ongoing Data Analysis.....	30
Trustworthiness: Enhancing the Quality of my Research Process and Data....	31
Chapter 4: RESULTS.....	33
Literature Review.....	33
Research on Moose and Winter Tick Interactions.....	33
Human Dimensions of Biodiversity Conservation and Wildlife Disease...	39
Results Organized by Data Generation Method.....	41
Interview Results.....	42
Questionnaire Results.....	61
Newspaper Article Results.....	64
Results Organized by Emergent Patterns.....	64
Chapter 5: CONCLUSION.....	69
Key Ideas Learned.....	69
Limitations and Recommendations.....	70
Future Research.....	71
References.....	71
Appendices.....	78
Appendix A: IRB Approval.....	79
Appendix B: Interview Recruitment Letter.....	80

Appendix C: Informed Consent.....	81
Appendix D: Interview Protocols.....	83
Appendix E: Literature Keywords and Databases including Number of Relevant Publications Identified.....	92
Appendix F: Summary of Literature Related to the Study.....	95
Author’s Biography.....	109



## LIST OF TABLES AND FIGURES

### Figures

Figure 1. Coding References for Moose health.....	46
Figure 2. Coding References for Recreation Opportunity.....	48
Figure 3. Coding for Recreation Opportunity by Interview Classification.....	50
Figure 4. Coding References for Cultural Identity.....	53
Figure 5. Coding for Cultural Identity Organized by Interview Classification.....	54
Figure 6. Coding References for Winter Tick Perceptions.....	56
Figure 7. Coding References for Disease Transmission.....	57
Figure 8. Coding References for Human Health.....	59
Figure 9. Coding References for Economic Vitality.....	61
Figure 10. Word Cloud for Newspaper Articles.....	64
Figure 11. Word Cloud for Interview Data.....	66
Figure 12. Word Cloud for Questionnaire Data.....	66

Tables

Table 1. Example of Literature Keywords used and Databases Searched	
Including Number of Publications Identified.....	20
Table 2. Newspaper Articles Identified.....	21
Table 3. Interview Participant Attributes.....	24
Table 4. Open-ended Questionnaire Questions and Number of Responses.....	26
Table 5. Word Frequency for all Stakeholder Groups Combined and by	
Individual Stakeholder Groups.....	43

## LIST OF ACRONYMS

MDIFW: Maine Department of Inland Fisheries and Wildlife

PN: Penobscot Nation

TBD: Tick-Borne Disease

## CHAPTER1: INTRODUCTION

### Background

Maine has one of the largest moose populations in the lower 48 states (Moose, 2019a) and moose have long been seen as one of the State's most iconic species—charismatic megafauna (Neuzil & Freedman, 2018). Moose are an integral part of Maine's culture and economy, particularly given their importance for hunting, wildlife-viewing tourism, and cultural identity. Given the economic, cultural, recreational and ecological importance of moose in Maine, it is important to understand potential perceptions of stakeholders on the stressors and drivers of moose population health. Winter ticks (*Dermacentor albipictus*), also known as moose ticks, are a parasite found on ungulates that have raised concerns about moose health in Maine. Heavy infestations of *Dermacentor albipictus* on moose have implications for a decline in overall health including anemia, skin irritation, hair loss, and in extreme cases death (*Winter tick*, n.d.).

Winter ticks are found on many large mammals in North America, mainly ungulates (Samuel, 2004). Winter ticks attach to their moose hosts from September to early November and feed on their hosts until they drop off to lay their eggs during March and April (Samuel, 2004). It is during the spring that the winter ticks reach the largest size, with the females reaching up to  $\frac{3}{4}$  of an inch long (Samuel, 2004). The impact of winter tick infestation on moose is the most visible in the late winter and early spring when moose can look a ghostly white, hence the nickname “ghost moose.” This whitish coloration in moose is triggered by winter tick infestation, which “causes moose to groom, thus breaking off much hair and creating the white appearance” (Samuel, 2004: 5).

## Justification/Significance

This study was conducted in order to understand the risk perceptions that multiple stakeholders have concerning moose-winter tick interactions in Maine, and the potential implications to the economy, cultural identity and practices, and recreation behavior. This project was funded by a University of Maine Interdisciplinary Undergraduate Research Collaboratives grant. The extent to which winter ticks impact moose, and specifically the moose population in Maine, is still not clear. Even less is known about how people perceive the risk associated with changing moose population health, and its effect on cultural-economic-recreation resources. The aim of this study is to gain a deeper understanding of how people perceive that winter ticks could be impacting moose and how this impact could affect human health, cultural identity, economic vitality, and recreation opportunities. In this study culture is interpreted broadly as the “complex whole which includes knowledge, belief, art, morals, law, custom, and any other capabilities and habits acquired by man as a member of society” as defined by British anthropologist Edward Tylor, cited by Kevin Avruch (1998: 6). Further, for this study we define cultural identity as the feeling of belonging to a group and/or category of people (Avruch, 1998). Understanding the socio-cultural and economic impacts that moose-winter tick interactions could be having could help fill the knowledge gap associated with social science research on risk perceptions of wildlife disease in Maine. Having a richer understanding of these multiple stakeholder perceptions can help better assess the likely impacts of winter ticks on Maine’s communities.

The work done on risk perceptions of moose-winter tick interactions is virtually nonexistent. No articles on risk perceptions and human dimensions of wildlife disease

were found specific to winter ticks and moose, hence the importance of this study. This is a large gap in the collective understanding of moose-winter tick interactions and how the public perceives the potential impacts of winter ticks on moose. Perceived risks can influence the acceptance of management strategies (Vaske, 2010) and understanding these perceptions can help agencies coordinate public outreach and further enhance the trust on the agency. Related human dimensions research could reveal weaknesses in the general public's knowledge of moose-winter tick interactions and how these weaknesses could be influencing people's risk perceptions related to moose and winter ticks.

Understanding the risk perceptions that people have about the moose-winter tick relationship and the current health of the Maine moose population is the foundation for studying the human dimensions of moose-winter tick interactions. It is important to understand the risk perceptions of wildlife diseases so that wildlife managers can develop proactive public involvement programs that consider the perceptions of the public as a whole (Bath, 1998). While there have been studies that show people believe wildlife management is important (LaBonte, et al, 2013), when it comes to risk perceptions of wildlife disease there are no studies related to moose and winter ticks. Numerous studies have tried to understand the drivers of wildlife disease risk perceptions associated with species such as deer. Oruganti et. al. (2018) found that hunters were generally knowledgeable about wildlife disease, in this case Chronic Wasting Disease, and that they were often more concerned about wildlife health than their own health.

Research on risk perceptions related to a decline in Maine's moose population may have implications for understanding the economic impacts that people perceive moose to have. Moose viewing tourism and moose hunting attract hundreds of visitors to

the state of Maine, draws locals to travel within the state for moose-related recreation purposes, and hence contributes significantly to the Maine economy. According to a statewide report, the total economic contribution (including direct and multipliers in employment, labor income and value added to the state) of hunting moose to Maine's economy in 2013 was over \$20,800,000, with a total annual expenditure of \$15,793,765 (Southwick Associates, 2014). Economic impacts play a huge role in how people perceive the impacts of winter ticks on moose. In addition to Maine's economy, moose are also culturally significant to the Penobscot natives in Maine (*Penobscot and the Moose*, 2011). Moose play a large role in many Penobscot legends and Penobscot people have been utilizing many different parts of moose for centuries (*Penobscot and the Moose*, 2011). These important roles of moose could contribute to how people perceive the risk of winter ticks.

Further, these data on stakeholders' perceptions could help wildlife management agencies and conservation organizations develop educational programs and messaging that targets gaps in knowledge and can influence the collective attitude of the public (Bath, 1998). Understanding perceptions related to trust in wildlife agencies and conservation organizations, and the acceptance of wildlife management is crucial to developing programs that have public support in regard to wildlife disease and efforts to mitigate disease transmission (Vaske, et al, 2009). Understanding risk perceptions related to moose and winter ticks could also help address concerns about potential cultural and economic impacts and increase awareness about the significance of the many different roles' moose play in Maine.

Since moose are such an iconic species in Maine, any negative impact to their numbers and health of population has the possibility to influence Maine's culture, economy, and recreational opportunities. To understand the scope of the moose-winter tick issue, more work has to be done to understand how a change in moose population could impact communities, industries, and cultures in Maine, hence the importance of addressing the human dimensions of the moose-winter tick system.

### Study Purpose

By using a qualitative approach, this thesis seeks to determine the risk perceptions that four stakeholder groups have about moose-winter tick interactions, and likely impacts on economy, recreation behavior, cultural practices in Maine. The stakeholders include wildlife managers, outfitters, Wabanaki citizens, and hunters.

### Organization of Thesis

This thesis is organized into the four following sections: the case of Maine, research methodology, results and discussion, and conclusions. Chapter 2 includes a background on the State of Maine and the significance of moose, as well as the current status of moose in Maine. Chapter 3, the methodology section, details the research approach and study design, as well as an introduction to the process of qualitative data generation and analysis. In the results section, I present the major ideas that emerged from the study; key results are presented alongside their interpretation. The final chapter, the conclusions section, details the key ideas learned, as well as the limitations of this study. This section also includes recommendations for future research.



## CHAPTER 2: DEFINING THE CASE

In qualitative research, case study methodology focuses on a phenomenon that exists within a defined context (Miles, et al, 2014), otherwise known as a case. The case is defined in terms of phenomena, place, time, and participants (Baxter & Jack, 2008). In this study, the case encompasses the risk perceptions of multiple stakeholder groups (hunters, outfitters, Wabanaki citizens, wildlife managers who participated in the study) in Maine during 2018-2019. The phenomenon of study is the risk perceptions of multiple stakeholders, the place is the State of Maine, and the time boundary is 2018 to present. I performed a search of literature relevant to the history and relationship of moose and Maine, using multiple databases sourced through Fogler Library's online database directory, to create a foundation for the importance of moose to Maine. Moose play a huge role in tourism and recreation in Maine, mostly associated with hunting. Moose contribute to Maine's economy in multiple different ways, according to Southwick Associates (2014) in 2013 travelers on moose hunting trips spent around \$15,800,000, with an average of \$2,639 spent by moose hunter in a year. Not only are moose an iconic species in Maine's culture and history, they also contribute significantly to "Vacationland's (as Maine is referred to) economy. In order to outline and define the context for this study I have provided the following sections on the demographics, culture, and economics of the State of Maine, as well as the significance and status of moose in the state.

### Maine Demographics, Culture, Economics

With 30,843 square miles of land, Maine has a population per square mile of 43 inhabitants (*US Census*, 2019). Maine is often considered to have one of the oldest

populations in the country. According to the US Census Bureau, 20% of Maine's 1,338,404 population is over 65 years old (*US Census*, 2019). Maine is a very rural state with many acres of forests, farm land, and coastline (*World population review*, 2019).

Maine is home to the Wabanaki confederacy which is composed of five major nations: the Mi'kmaq, Maliseet, Passamaquoddy, Penobscot and Abenaki (*Wabanaki*, 2019). While the Wabanaki confederacy was disbanded in 1862, the nations are still present in Maine and include over 7,800 members (*Wabanaki*, 2019). These nations manage their own lands and set their own moose hunting permit limits.

Maine's nickname "Vacationland" hints that it has long been seen as a tourist destination. The tourism industry supports a large portion of Maine's economy: in 2016, tourists spent almost \$6 billion in Maine (*Maine*, 2016). Along with tourism, in 2011 Maine was "the second-largest paper production state" (*Economic History of Maine*, 2015). Maine is also known for its famous Maine lobster (*World population review*, 2019).

### Significance of Moose to Wabanaki Culture

Moose have long been part of Wabanaki culture and can be found in many cultural stories. In one story presented in the pamphlet *Penobscot and the Moose*, The Wabanaki hero Gluskabe stomps moose out of the ground to provide food for the hungry Wabanaki people. In another traditional story, Gluskabe chases down a giant moose who is threatening people and kills him, scattering the moose's entrails around Penobscot bay to create landmarks (*Penobscot*, 2011). Moose have a strong presence in Wabanaki oral traditions and cultural history.

In addition to its cultural significance, moose have also been used for centuries as a source of meat and other resources. There are many Wabanaki traditions that rely on moose and all of the resources it can provide. James Eric Francis Sr., the Tribal Historian for the Penobscot Nation wrote that moose “has provided our culture with food, medicine, clothing, and tools. The moose has reached legendary proportion in both oral history and literature” (*Penobscot*, 2011). Moose are an essential resource: "from food to medicine, from moose skin to clothing, moccasins, boats and sails to rawhide straps, moose hair embroidery and moose bone pipe bowls, a moose was a veritable department store on hooves" (Prins, 2007). Moose hides are still used today as a source of material for cultural crafts, in particular to build drums (Interview with Wabanaki citizen, October 1, 2018) and Moose are a very significant species to the culture and history of Wabanaki people and still serve as an integral food source for Penobscot citizens.

### Significance of Moose in Maine

Moose contribute to Maine’s culture of hunting and outdoor recreation and presents the image of Maine as a wild and untamed destination to tourists. Current objectives for the moose population in Maine provided/established by the Maine Department of Inland Fisheries and Wildlife include managing the population for hunting and viewing opportunities (*Moose*, 2019a). Moose contribute to Maine’s economy through “wildlife viewing, tourism revenue, and hunting permits and related expenditures” which generate “millions of dollars annually” (Wattles & DeStefano, 2011: 59). Moose have become a symbol of the State, from being the Maine state animal to

being featured front and center on Maine's flag, moose seem to have become part of what makes Maine, Maine.

### Historical and Current Moose Status and Disease

In the 1600's, early explorers wrote that there were many moose to be found in Maine. These populations dropped, most likely due to unrestricted hunting, until the 1900's when hunting laws were put into place (*Moose*, 2019a). There have been many changes to moose hunting laws over the years including season limits, bag limits, and permitting systems. In 2018, 2,523 moose hunting permits were issued, an increase of 417 from 2017 figures (*Moose*, 2019b). Of these 2,523 permits, only 247 were issued to non-residents. These permits are issued for specific management districts in the state, which help facilitate population management (*Moose*, 2019b). In the early 1900's, the moose population was estimated to be around 2,000 individuals (*Moose*, 2019a). The current moose population in Maine is estimated to be around 76,000 moose (*Moose*, 2019a).

Moose populations and hunting permits have been managed by the Maine Department of Inland Fisheries and Wildlife (MDIFW) since 2000 when the legislature turned all management over to the department (*Moose*, 2019a). While moose-vehicle collisions have decreased since then (Wattles & DeStefano, 2011), there is rising concern about the effects of parasites on the Maine moose population. According to a report on moose status and management, there is a need for more research on the "impacts of parasitism by winter tick (*Dermacentor albipictus*) and brain-worm (*Parelaphostrongylus tenuis*) on productivity and mortality of moose" (Wattles &

DeStefano, 2011). Wattles and De Stefano also highlight the need to understand the “influence of climate change on population dynamics and range” in order to evaluate the future of moose populations.

There are currently 26 wildlife management districts in Maine, all of which have specific management goals and objectives related to moose (*Moose*, 2019a). These goals include “maximize hunting and viewing opportunity while maintaining the availability of mature bulls,” “balance the public’s concern about moose/vehicle collisions with the public’s desire to hunt moose,” and “reduce moose/vehicle collisions” (*Moose*, 2019a). One of the objectives stated by the MDIFW to mitigate moose-vehicle collisions was to reduce the moose population by one third between 2000 and 2015 (*Moose*, 2019a). While moose have by no means disappeared from Maine, the impact from parasites and changing habitats is largely unknown, along with the implications of these factors for the future of the moose population in Maine.

## CHAPTER 3: METHODOLOGICAL APPROACH

This honors thesis uses a qualitative approach to analyze the risk perceptions that multiple stakeholders have about moose-winter tick interactions. Qualitative research can be very valuable in gaining an in-depth understanding of risk perceptions and helping to understand what frames the attitudes and behaviors of individuals. As stated by Miles et al, qualitative data can be used in “locating the meanings people place on the events, processes, and structures of their lives and for connecting these meanings to the social world around them” (2014: 11). Qualitative research is valuable because it is specific to the time, place, and people who are part of a study. Focusing on “locally, temporally, and situationally limited narratives” (Flick, 2009: 12), allows qualitative researchers to understand the dynamics and perspectives of specific circumstances. Qualitative research is also flexible in order to allow the context of the study to mold the research process: “flexibility is controlled opportunism in which researchers take advantage of the uniqueness of a specific case and the emergence of new themes” (Huberman & Miles, 2002: 16).

The aims of this study are to (1) understand a range of meanings that participants place on moose, and the association between winter ticks and moose within the context of Maine, and (2) how these meanings connect to their social lives, hence, focusing on people’s real-world experiences (Miles, et al, 2014). In the case of winter ticks and moose, qualitative methods can help us understand what people think about the moose-winter tick relationship and how they believe it could directly and/or indirectly impact Maine’s culture, economy, and recreation opportunities.

### Researcher's Role—Researcher-as-Instrument

My role as a researcher in this study was to generate and analyze the multiple meanings participants place on moose, the relationship between moose and winter ticks, and likely impacts on human activities and livelihoods. When it comes to qualitative research, the researcher plays a key role in not only data generation, but data interpretation. Ely writes that as an instrument, the researcher can find “personal control and personal responsibility, and, therefore, personal creativity” (1991: 86) when interacting with the data. My implicit values and positionality have an impact on the way I interact with the data: “the words we attach to fieldwork experiences are inevitably framed by our implicit concepts” (Miles, et al, 2014). Through the development of interview questions, the facilitation of interviews, and the analysis of the data, I influenced the research process through my values and interpretation. My background, experiences, education, and perceptions of the issues framed data generation, analysis, and interpretation strategies. Since what I hear and see cannot be objective, my interpretation of the data makes me a tool of the research process (Ely, et al, 1991: 86).

To help clarify my stance, I briefly present some information on my background, my values and point of view in relation to this research. I grew up in New England, surrounded by people who cared deeply about having healthy deer and moose populations. Having lived in New England, I have also had first hand experiences with many species of ticks, but winter ticks was never one of them. This research introduced me to winter ticks and the complex biological and social relations in Maine. Although I am not a hunter and have never experienced a moose hunt or the meals that follow, I have a great respect for people who hunt for sustenance and value the culture of hunting in

Maine. I have spent my time at the University of Maine studying ecology and environmental science, as well as parks, recreation, and tourism. I have also worked as an undergraduate research assistant for the School of Forest Resources at the University of Maine performing visitor surveys, assisting with focus groups, and expanding my knowledge of social science research. These experiences have opened my eyes to the value of qualitative research and how it can provide an outlet to understand people's experiences. Knowing that the perceptions and experiences that individuals have can be valuable to informing research has given me a stronger appreciation for what this study could contribute to the issue of moose-winter tick interactions.

I believe that analyzing people's attitudes and perspectives about the moose-winter tick dynamic can help us understand the risk that people believe winter ticks pose to moose, as well as Maine culture, economy, and social structure. This qualitative research approach can also give a voice to individual stakeholders and their experiences with moose and winter ticks. Public perceptions and advocacy about moose management can inform/support decisions by wildlife managers and politicians to make certain management decisions. This qualitative case study presents an opportunity to gain an in-depth understanding of and give a voice to diverse perspectives and groups on their view and experiences with winter tick and moose interactions, their role in overall moose wellbeing and health, and the potential impacts on people, culture and the economy.

### Research Methodology

In order to frame my research, I utilized an instrumental single case study research methodology. Case study methodology "facilitates exploration of a phenomenon within its context using a variety of data sources" (Baxter & Jack, 2008: 544). A case



study methodology was chosen because I wanted to understand different meanings and perceptions about moose-winter tick interactions between stakeholder groups within the context of Maine as a bounded system (Yin, 2003).

A case is defined by Miles and Huberman as “a phenomenon of some sort occurring in a bounded context” (1994: 45). In this research, I employed a single case study methodology with embedded units which involves looking at “sub-units that are situated within a larger case...data can be analyzed within the subunits separately (within case analysis), between the different subunits (between case analysis), or across all of the subunits (cross-case analysis)” (Baxter & Jack, 2008: 550). The case for this study was defined as the risk perceptions of moose-winter tick interactions held by multiple stakeholder groups, the sub-units (hunters, outfitters, Wabanaki citizens, wildlife managers who participated in the study), in Maine during 2018-2019. Having embedded subunits allowed me to look at the differences in risk perceptions between different stakeholder groups. The design allowed for triangulation across sources of information (stakeholder groups) and data generation techniques (i.e., semi-structured interviews, open responses to a questionnaire distributed to Penobscot Nation citizens, and archival evidence).

I employed an instrumental case study design, which is used when the researcher “focuses on an issue or concern and then selects one bounded case to illustrate the issue” (Creswell & Poth, 2018: 98). In this study the concern is risk perceptions of moose-winter tick interactions within the case of Maine from 2018 to present. This approach allowed me to utilize the relationship of moose to Maine in order to better understand how stakeholders perceive the impacts of winter ticks on moose, as well as other indirect

impacts from moose-winter tick interactions. The other two variations of case study methodology are multiple case study and intrinsic (Creswell & Poth, 2018). A multiple case study variation allows the researcher to address one concern with multiple cases (Creswell & Poth, 2018). This study only utilizes one case, so it would not qualify for a multiple case study variation. Intrinsic case studies are ones where the “focus on the case itself...because the case presents an unusual or unique situation” (Creswell & Poth, 2018: 99). This study would not lend itself well to an intrinsic variation because I am interested in the issue of the risk perceptions of moose-winter tick interactions *within* the case, not the case itself. While it is unknown how winter ticks could be impacting Maine through impacts to moose, this instrumental single case study design allowed me to look at perceptions of potential impacts to human populations, cultures, ecosystems, and economies in Maine.

### Ethics

As a social science research project that involved data generation with human subjects, qualitative research can be ethically complex given the level of interactions and voices sought to be heard. Since this study deals understanding people’s viewpoints and opinions, all of the interview protocols, consent forms, and recruitment scripts had to be approved by the Institutional Review Board (IRB) at the University of Maine. This review process is done to verify that the questions I would be asking interview participants would not violate the welfare of human subjects. One goal of having my research instruments approved was to guarantee participants that this study was being conducted ethically and under the supervision of the University of Maine IRB. Since qualitative research is based on the personal experiences and perceptions of individuals

(Miles, et al, 2014), it is important that the privacy of all study participants is maintained. This review is meant to maintain the integrity of my research and was required before I could reach out to potential participants and conduct interviews.

### Defining the Stakeholder Groups

In order to create a case study that incorporated multiple perspectives, initially three different stakeholder groups were defined: hunters, outfitters, and Wabanaki citizens. These groups all represent people who place significant value on moose and rely on these animals in multiple ways and for different purposes. Hunters need healthy moose populations in order to hunt and rely on high levels of permits to get the chance to hunt moose. There are also hunters who hunt for subsistence and rely on moose as a source of food. Outfitters are often involved with moose hunting and provide hunters with guides and lodging. These outfitters rely on hunting to bring in business. Other outfitters capitalize on the allure of moose viewing and need healthy moose populations in order to market to tourists who want to see or photograph moose. Wabanaki citizens have a special relationship with moose and rely on moose for sustenance and cultural maintenance, including the creation of instruments like drums and other traditional crafts. Besides moose being important for the “vacationland” State, the stakeholder groups targeted in this study place a particularly high value on moose and can provide insight on the cultural, social, economic, and environmental role that moose play in Maine.

During data generation and responding to the iterative and open-ended nature of qualitative research (Turner, 2010), I was able to reassess the stakeholder groups that I was targeting and found that another group needed to be included to have a more holistic view of the problem: wildlife managers. This stakeholder group includes people who

work more closely with moose population management in Maine and who in general have a more in-depth knowledge about the moose-winter tick relationship. Wildlife managers contributed a more biologically based perspective to the case study and helped capture people with greater firsthand experience with winter ticks. While this case study incorporated four stakeholder groups, it is important to emphasize that multiple participants belong to/identify with various stakeholder groups.

### Selecting the Participants

The process of reaching out to potential participants was one of the most difficult parts of this case study. While the stakeholder groups provided a framework for reaching out to and identifying potential interviewees, contacting and performing interviews was much more difficult than I had anticipated. The majority of potential participants were found using the internet and searching for people that fit into the defined stakeholder groups. Outfitter and guiding service websites were one of the main sources of contact information. I reached out to potential participants who were recommended by members of my thesis committee and was also introduced to some potential participants through my committee members. As part of the recruitment process, I emailed a brief description of the aim of the study and a copy of the interview consent form to potential participants and requested they contact me by email or phone if they were willing to participate.

In order to build rapport and trust with potential interview participants, I included information about myself and the nature of my study in the initial recruitment email. Gaining entry is a crucial step in the qualitative research process so as to establish trust between myself as the researcher and any potential participants (Shenton & Hayter,

2004). Details included my affiliation with the University of Maine, my school of study, and that I was working under the supervision of Dr. Sandra De Urioste-Stone. If the potential participant had been recommended to me, I included the name of who had recommended them to gain entry, build trust and enhance the credibility of the study.

Further, I employed the snowball participant selection strategy to gain more recommendations for potential interviewees. Snowball, or chain referral selection strategy, consists of “asking well situated people to nominate people who can provide insight into a phenomenon because they know a lot about it” (Emmel, 2013: 40). This participant selection technique allowed me to build on study participants’ knowledge about the topic and social network in order to reach out to other potential stakeholders with information about the case. The combination of the snowball participant selection strategy and my utilization of the internet allowed me to reach out to many potential participants through email. While these techniques were quite useful, I had difficulties getting potential participants to respond to me. These low levels of response limited my ability to get an equal representation from all stakeholder groups from all counties of Maine. Given the limited time for fieldwork for honors students, this study would benefit from further study as part of a master’s research where there is significant time to gain entry, build rapport and trust, and reach out to more potential interviewees, all key elements in qualitative research (Shenton & Hayter, 2004).

#### Data Generation Methods

Case study research requires multiple data generation methods in order to strengthen the understanding of the issue. As Baxter & Jack put it, “each data source is one piece of the ‘puzzle,’ with each piece contributing to the researcher’s understanding

of the whole phenomenon. This convergence adds strength to the findings as the various strands of data are braided together to promote a greater understanding of the case” (2008: 554). My data generation techniques included a review of archival evidence (i.e., scientific literature, newspaper articles, cultural stories), semi-structured interviews, open-ended responses from a questionnaire targeting Penobscot Nation citizens, and my reflective journal. As part of the case study methodology, it is essential to integrate multiple sources of information that allows for data triangulation during data analysis and interpretation (Yin, 2014). It is important to use multiple data generation methods in qualitative research in order to enhance credibility and develop a strong understanding of the phenomenon using different perspectives and types of information (Baxter, 2008). Following is a description of these data generation methods and their suitability for my case study research methodology.

### Review of Archival Evidence

The review of archival evidence included the identification and analysis of books, journal articles, newspaper articles, reports, and pamphlets that provided a foundation for understanding (1) what research had been done to understand the dynamic between winter ticks and moose, as well as risk perceptions that people have about the impacts of winter ticks on moose, (2) Wabanaki cultural traditions and creation stories regarding moose and ticks, (3) and the importance of moose to the State of Maine and its people. To identify potential books and book chapters, I used scientific publication databases available through Fogler library, using a combination of keywords in order to compile relevant publications (Table 1). After reading through the sources I gathered using this

method, I narrowed down the list of sources to only pertinent studies that specifically addressed winter ticks (three), winter ticks and moose (ten), moose disease (seven), or frameworks for understanding risk perceptions of wildlife disease (four). From these publications, I analyzed the different research approaches studies had used, any practical implications pertaining to winter ticks and moose that were presented, and the major conclusions of the publications. In determining how well researched this topic is and what research could be done in the future, I was able to frame the relevance of my research in the context of prior studies.

Table 1. Example of Literature Keywords used and Databases Searched Including Number of Publications Identified

Keywords			Databases with Number of Publications Returned				
Keyword 1	Keyword 2	Keyword 3	Ebscohost	Jstor	Ingenta	Cabi	Web of science
perception*	hunter*	moose	4	0	1	5	5
meaning*	hunter*	moose	6	0	2	1	0
symbol*	hunter*	moose	6	0	0	0	0
symbol*	hunter*	tick*	7	0	0	0	0
meaning*	hunter*	tick*	2	0	0	0	0
perception*	hunter*	tick*	0	0	0	1	0
perception*	outfitter*	moose	0	0	0	0	0
meaning*	outfitter*	moose	0	0	0	0	0
symbol*	outfitter*	moose	0	0	0	0	0
symbol*	outfitter*	tick*	1	0	0	0	0
meaning*	outfitter*	tick*	0	0	0	0	0
perception*	outfitter*	tick*	0	0	0	0	0
symbol*	moose	Maine	6	0	0	0	0
"first nation*"	moose	Maine	2	0	0	0	0
tourism	moose	Maine	32	0	0	1	0
tourism	tick*	Maine	4	0	1	0	1
moose	health	Maine	30	0	0	5	2
moose	disease	Maine	22	0	2	12	2

Table 1. Continued

Keywords			Databases with Number of Publications Returned				
Keyword 1	Keyword 2	Keyword 3	Ebscohost	Jstor	Ingenta	Cabi	Web of science
moose	economy	Maine	11	0	1	1	0
zoonotic	disease	Maine	74	0	209	38	1
zoonotic	moose	Maine	4	0	0	1	0
zoonotic	perception*	Maine	0	0	2	0	0
recreation	moose	maine	65	0	0	0	0
recreation	tick*	maine	0	0	0	0	1
culture	moose	maine	0	0	0	1	0
"risk perception*"	behavior	hunting	71	0	2	5	5
"risk perception*"	behavior	tourism	94	1	8	73	50
<b>Total relevant per database:</b>			<b>25</b>	<b>0</b>	<b>15</b>	<b>14</b>	<b>1</b>

In addition to the literature review, I also performed a review of newspaper articles, using a google search, in order to get a better understanding of what perceptions the media is presenting about winter ticks and moose (Table 2). This source was used in order to assess what information is being distributed to the public about winter ticks and what common topics exist between what the media presents and what stakeholder believe. This newspaper article review also contributed to the overall understanding of how people perceive winter ticks to be impacting moose, and the social system.

Table 2. Newspaper Articles Identified

Article Title	Author	Date	Area referenced
Ticks, Thriving in Warm Weather, Take a Ghastly Toll on New England Moose	Bidgood, Jess	January 19th, 2017	New England



Table 2. Continued

<b>Article Title</b>	<b>Author</b>	<b>Date</b>	<b>Area referenced</b>
As Moose Populations Decline, Hunting Permits At Historic Lows	Blechl, Robert	July 31st, 2018	New England
Bled, scraped and starved to death: Exploding tick numbers threaten this New England beast	Fears, Darryl	October 7th, 2015	New England
Winter ticks raise concerns about future of Maine’s moose herd	Fleming, Deirdre	June 14th, 2014	Maine
Cut hunting permits 24 percent so public sees more Maine moose, plan urges	Fleming, Deirdre	February 25th, 2016	Maine
Decline in winter ticks on moose bodes well for hunters	Fleming, Deirdre	January 26th, 2018	Maine
Blood-sucking ticks are killing huge numbers of moose, researchers say	Francovich, Eli	August 28th, 2017	Maine, New Hampshire
Efforts needed to save our moose from ticks	Hallee, Roland	March 21st, 2018	Maine
Seeking ‘Healthy’ Herd, Biologists Propose 20 Percent Increase In Moose Permits	Holyoke, John	August 21st, 2010	Maine
Moose-killing ticks thrive in shorter winters due to climate change	Koons, Stephanie	March 3rd, 2017	New England
Climate Change Is Killing New England’s Moose. Are Hunters the Answer?	Kusnetz, Nicholas	May 29th, 2017	New Hampshire
Winter ticks threaten Maine moose	O’Connor, Lexie	n.d.	Maine
Ticks annihilate New England moose	Schmitt, Kristen	January 18th, 2017	New England
Data: Moose-Car Collisions Down More Than 50 Percent In Last Decade In Maine	Sharon, Susan	September 24th, 2018	Maine
Good news! Only half of our moose calves died this winter	Smith, George	May 26th, 2017	Maine

In order to learn more about Wabanaki culture and the significance of moose, I researched stories through websites and a tribal pamphlet about moose. This review contributed to my understanding of traditional uses of moose and the cultural significance that moose play in Wabanaki life. These sources were summarized into tables along with

their key ideas in order to synthesize the data prior to creating my database in NVivo 12 Plus.

### Semi-structured Interviews

These formal qualitative interviews with open-ended questions (Turner, 2010) were conducted in-person with nine stakeholders in order to gain insights into their perspectives about winter ticks and moose, their knowledge of winter tick dynamics, and their concerns about negative impacts from winter tick-moose interactions on the social and ecological systems. The questions were created to be open-ended because it “allows the participants to contribute as much detailed information as they desire, and it also allows the researcher to ask probing questions as a means of follow-up” (Turner, 2010). These semi-structured interviews included open-ended questions that addressed the issue of winter ticks through moose health, human health, recreation opportunities, cultural identity, and economic vitality.

To recognize the different roles and potential perceptions, we developed and used different interview protocols for each of our target stakeholder groups. Of the nine participants, three were categorized as outfitters, three as Wabanaki citizens, and three as wildlife managers (Table 2). Of these nine, only two did not identify as hunters. All of the interviews were tape-recorded to ensure meanings of participants were captured and to be able to revisit the conversations to gain a deep understanding of meanings and the context of the ideas presented. I also jotted some shorthand notes during the interviews to capture key ideas (Bernard, et al, 2017). Table 3 details some of the attributes of the interview participants. The majority of the participants were male, and most were

categorized as middle-aged. Two participants were affiliated with the Maine Department of Inland Fisheries and Wildlife and two were affiliated with the Penobscot Nation.

Table 3. Interview Participant Attributes

Attributes		Number of Participants
Gender	Male	6
	Female	3
Age	Young	1
	Middle-aged	6
	Senior	2
Affiliation	MDIFW	2
	PN	2
Protocol	Wildlife manager	3
	Outfitter	3
	Wabanaki citizen	3

I conducted these interviews over the course of six months in 2018. The different stakeholder groups allowed me to approach this issue from the context of people engaging with and relying on moose in multiple ways. The semi-structured nature of these interviews allows the interviewer to “modify the order and details of how topics are covered” (Bernard, et al, 2017: 76). This allowed me to be flexible with the protocol and

elaborate on questions, being able to respond to hunches or follow up on new ideas shared by participants (Bernard, et al, 2017).

There were multiple challenges that I encountered when conducting these interviews. One of the foremost difficulties was deciding which protocol to use for participants who fell into multiple stakeholder categories. Since I found so many people identified as hunters while also being an outfitter, wildlife manager, or Wabanaki citizen, I chose to prioritize the other protocols over the hunter protocol. Another challenge for me was navigating interview questions that the participant had already answered so as to not be repetitive (Reflective journal, 7/17/18: 7/25/18: 7/26/18). The participant recruitment for these interviews was the most challenging aspect of the research process. I found it difficult to connect with willing participants and coordinate interview dates and times. Being flexible about location and offering to conduct interviews over the phone increased the number of stakeholders I was able to interview.

Audio recordings were transcribed verbatim--word for word--in order to preserve the accuracy and rich personal accounts of participants (Bernard, et al, 2017) into a document that I could analyze. This word for word transcription was essential to stay close to the words and meanings of participants; further, having verbatim transcription was important to allow for open data analysis to occur: "In Vivo coding uses words or short phrases from the participant's own language in the data record as code" (Miles, et al, 2014: 74). This In Vivo coding method that I utilized required that the words of the participant be presented exactly as they were said in order for the analysis to be accurate (Bernard, et al, 2017).

### Open-ended Questionnaire Responses

An online questionnaire was sent out to Penobscot Nation citizens to learn more about what Penobscot citizens know about winter ticks and what risk perceptions they have associated with a decrease in moose health. This primarily quantitative questionnaire included mostly close-ended questions and Likert scales. In addition, the instrument included four open ended questions that allowed participants to provide a written description pertaining to ticks, winter ticks, and moose. The number of responses to the four open-ended questions ranged from 41 to 53 (Table 4). This questionnaire allowed a larger pool of Penobscot Nation citizens to provide their perspectives on winter ticks and moose health, along with the importance of healthy moose to their culture.

Table 4. Open-ended Questionnaire Questions and Number of Responses

Question	Number of Responses
In your opinion, what are the greatest threats from an increase in the tick population on tribal lands?	53
In your opinion, what is a winter tick? (All people who said they had heard of winter ticks)	41
In your opinion, what does it mean for a moose population to be healthy?	50
What would be some of the impacts to you personally in response to a decline in the moose population? (Only Individuals that responded that a decline would pose a "serious" or "very serious" threat to them personally)	46

### Reflective Journal

I kept a reflective journal throughout the process in order to track my thoughts and new ideas, as well as any changes to the process that I thought would be beneficial to

the overall research endeavor. This process helped to establish the validity of my research through detailing my data generation and analysis procedures (Creswell & Miller, 2010). I completed a journal entry after every interview to highlight the major ideas and anything that stood out to me. This also allowed me to keep track of emerging key topics. During the analysis of the data the reflective journal served to catalogue any changes I made as well as topics and connections within the data. I also recorded my own thoughts and feelings in these reflections in order to maintain an awareness of how my personal values could impact my analysis of the data. These reflections serve to detail “what occurred in the research process, what has been learned, the insight this provides, and the leads this suggests for future research” (Ely, et al., 1991: 80). These reflections provided insight into preliminary themes and allowed me to begin analysis early on in the process.

#### Usefulness of the Data Generation Methods Used

The data generation tools used all contributed to different goals of this study. Through the interviews I was able to engage openly with stakeholders and ask direct questions about their experiences with and perceptions of winter ticks in Maine, and probe participants when needed further clarification about meanings shared. This method allowed me to have longer conversations with participants and better understand their relationship to moose and how winter ticks could impact them. This method was the most constrained by time and a longer interviewing window could have given me the opportunity to reach out to more potential participants.

The responses to the open-ended questions were drawn from a larger questionnaire that was developed and distributed by James Elliott, a graduate student in the School of Forest Resources, which asked about experience with ticks, winter ticks,

and the importance of moose. The questionnaire was administered online and was opened in late October 2018. It was closed on January 22, 2019. Participants were recruited through the Department of Natural Resources (DNR) E-Newsletter, the DNR Website, the DNR Facebook page, the Penobscot Nation (PN) Community Flyer, the PN Website, and word of mouth/friends/email. This questionnaire was only distributed to Penobscot Nation citizens so the perspectives it provides only pertain to one of the stakeholder groups targeted in this study. These four questions were useful because they reached a larger pool of participants and gathered a wider range of opinions and perspectives. While these responses cannot be analyzed within the context of the respondent, they can be used to develop common topics within the context of Wabanaki culture.

The review of archival evidence provided a solid foundation for my understanding of the research topic that has been previously conducted, primarily to understand biophysical research on moose and winter ticks, and secondly on human dimensions of wildlife and health risk perceptions. Having this foundation allowed me to frame the risk perceptions generated through the interviews and questionnaire within the context of the current scientific understanding of moose-winter tick interactions. With that being said, I found that there have not been many conclusive studies pertaining to the impact that winter ticks could be having on moose. The literature review helped me identify gaps in the literature surrounding the dynamics of the relationship between winter ticks and moose and its implications to moose population health.

Finally, the reflective journal served to help organize my thoughts and keep track of the common topics that I found (Ely, et al, 1991). It also helped me see that my research could contribute to some of the gaps in the current literature by providing insight

into risk perceptions. The reflective journal acted as a log for changes that I made to the protocol as I continued to adapt it to the interviews. It also helped me keep track of my potential biases and personal perceptions. This is important because it allowed me to acknowledge the areas where my perceptions might influence my analysis of the data.

#### Organization of Data, Database Creation, Data Entry and Management

All of the transcribed interview recordings were added as word documents into my NVivo 12 Plus database. The open-ended questionnaire responses were also added to this database as an Excel spreadsheet. Using a computer software program in qualitative data analysis can be very useful. These programs can allow the researcher to easily store data, find relevant evidence in the database, visualize information, and analyze “how different participants spoke about different topics” (Creswell, 2016: 181). NVivo is an analysis software that helped me to organize and analyze different textual patterns in my data (Miles, et al, 2014). Miles, Huberman & Saldana summarize data analysis as "three concurrent flows of activity: (1) data condensation, (2) data display, and (3) conclusion drawing/verification" (2014: 12). The software facilitated this by allowing me to compile my data in a database, organize and visually explore the data, and interpret connections and major topics. NVivo allowed me to assign codes and associated descriptions, create categories descriptions while grouping data by different criteria in order to look at emerging patterns and connections between keywords.

Bazeley & Jackson summarize the coding process the following way: "organizing concepts into coding hierarchies...helps to clarify...patterns of association" (2007: 95). These patterns helped build an understanding of the different risk perceptions that



stakeholders had and facilitated ongoing data analysis and recording of materials. These patterns of association became easier to visualize with the help of NVivo's text search and word frequency query capabilities. These functions allowed me to see which words were mentioned the most frequently and what other words they were commonly associated with (Bazeley & Jackson, 2007).

### Ongoing Data Analysis

Data analysis for a qualitative study like this one is an ongoing process: Creswell and Poth write that "the process of data collection, data analysis, and report writing are not distinct steps in the process-they are interrelated and often go on simultaneously in a research project" (2018: 185). The data analysis for this project began with my very first interview and has been ongoing since then. From interviewing to reflecting to analyzing the text, I was constantly engaging with the data. My reflections allowed me to adjust my interview protocol to produce the most efficient and effective engagement with participants. These reflections also allowed me to begin analysis even before the data was added to my NVivo database.

In the first phase of my analysis, before the creation of my NVivo database, I was collecting relevant articles for my literature review and relevant newspaper articles, transcribing interviews, and writing reflective journal entries. My reflective journal allowed me to begin highlighting common topics and reoccurring perceptions that were present in the interviews.

The second phase of my analysis began once I imported the transcribed interviews, newspaper articles, and reflective journals into NVivo. The questionnaire

responses were also added to NVivo later on in this phase. While utilizing NVivo, I began with a microanalysis approach. This involves detailed line-by-line analysis of the text in order to generate categories of meaning, nodes, and to outline possible relationships among these nodes (Strauss & Corbin, 1998). Throughout the process of analysis, I used the categories to note patterns, explanations, causal flows, and propositions (Miles, et al, 2014). These categories changed throughout the process as I rearranged and added nodes, explored patterns and themes, and ran text searches using NVivo.

I found that utilizing text searches and word frequency queries were the most useful tools to help me review and revise my categories and nodes. This allowed me to establish new patterns in the data and reinforce patterns I had noted in the first phase of analysis. This second phase supported the condensation of my data and the creation of visual tools in order to conceptualize the patterns. This process resulted in conclusions drawn from these patterns of association and what Bazeley & Jackson call thick description: an interpretation of data that can “convey deep understanding of a culture or experience” (2007: 244). As a tool of the research, I have been constantly processing, interpreting, and visualizing the data by engaging with the words and phrases of the data.

#### Trustworthiness: Enhancing the Quality of my Research Process and Data

To ensure that my research was high quality, it was important for me to evaluate my research process and the data I generated (De Urioste-Stone, et al, 2018). In order to enhance the quality and trustworthiness of qualitative research, De Urioste-Stone et. al., recommend utilizing “thick description of the case, triangulation strategies, and case

bounding” (2018: 418). In this context, trustworthiness is the “quality of an investigation and its findings that make it noteworthy to audiences” (Schwandt, 2001: 258).

Triangulation is used to check the integrity of references drawn from the data (Schwandt, 2001). I utilized multiple data sources to cross reference and verify the validity, the truth and certainty (Schwandt, 2001), of my conclusions. I also employed the use of a rich description of the case to “allow other researchers to understand the transferability of results to other situations and settings,” which is another aspect of the validity of a case study. In addition, I kept an audit trail through my reflective journal to verify the dependability and confirmability of my research (De Urioste-Stone, et al, 2018). The results chapter of this thesis presents the outputs of this analysis. The results have been organized to present how stakeholders believe winter ticks are negatively impacting moose and then key topics related to how the dynamic between moose and winter ticks could affect recreation opportunities, cultural identity, economic vitality, and human health.

## CHAPTER 4: RESULTS

### Literature Review

There is little known about how winter ticks are impacting moose in Maine, and what could be the implications to Maine's economy, communities, businesses, and cultural traditions. In an attempt to understand what aspects of the dynamic between winter ticks and moose have been previously explored, and likely effects on human systems, I conducted a review of the existing literature. For conducting the literature review, I established three areas of focus to understand the impacts of moose-winter tick interactions on human systems: the ecology and disease potential of winter ticks, the direct impact that winter ticks are having on moose, and the risk perceptions associated with winter ticks and moose.

### Research on Moose and Winter Tick Interactions

There are multiple studies from the scientific literature on moose-winter tick interactions (McLaughlin & Addison 1986; Peterson, 1955; Samuel, 2007). While I was able to find some studies about the biological impact of winter ticks on moose, none were especially conclusive about how and why winter ticks could have negative effects on moose. A book on moose and winter ticks suggested that "if tick numbers are sufficient there will be an energy cost, a drain to moose" (Samuel, 2004: 35) and suggested that anemia from blood loss, damage to winter hair, reduced fat stores, decreased time spent feeding, and reduced growth in calves could all be related to winter ticks. A study found that winter ticks can cause physical impacts, such as "destruction of winter hair, reduction in respiratory minute volumes, and respiration rates of heat-stressed moose"

(Welch, et al, 1990: 4). Multiple studies cite the fact that winter ticks can cause hair loss in moose and that this could influence winter survival rates due to loss of heat (Addison, et al, 1994; McLaughlin & Addison, 1986; Samuel, 1991). Fenstermacher (1934) argued that, while winter ticks can play a role on survival, many factors can decrease moose vitality. These other factors can include weather, habitat, and moose density (Pybus, 1999; Samuel, 2007). Most of the research I found focused on external factors that can influence moose mortality and the physical impacts that winter ticks can have on moose.

There is little research that explores possible disease transmission from winter ticks to moose, as well as a gap in the literature on the biological mechanisms behind how winter ticks could contribute to moose mortality. The literature on disease transmission from winter ticks to moose found no evidence of winter ticks as a vector of disease (Fenstermacher, 1934; Jellison, 1933; Peterson, 1955). Two studies that focus on the physical impacts of winter ticks on moose, and moose populations, cited weather conditions as contributing factors to moose death (Pybus, 1999; Samuel, 2007); it is clear that winter ticks are just one aspect of a larger set of pressures on moose in Maine.

The negative biological impacts that winter ticks are having is a critical area of study in order to better understand the extent to which these ticks may affect moose. One of the earliest studies that focused on the relationship between winter ticks and moose was done in 1933 by Jellison; he found that while winter tick was the only constant parasite on diseased moose, there was no transmission of disease to inoculated guinea pigs (Jellison, 1933). This disproved a study done the year before by Thomas & Cahn (1932) that found that guinea pigs seemed to contract a disease after being artificially infested by engorged ticks. Jellison concluded that winter ticks could play a role in moose

debilitation, but that there was little evidence for disease transmission (1933). These conclusions were largely based on observational data, and a study a year later in 1934 found that winter ticks were not necessarily found on all diseased moose (Fenstermacher, 1934). Fenstermacher also found there was no transmission of disease from winter ticks and concluded that many factors reduce moose vitality versus any one pathogen. As of the 1950's, there were no conclusive findings beyond the observation that winter ticks seemed to weaken moose and made them more vulnerable to disease (Peterson, 1955).

Deviating away from disease ecology or biological impacts, McLaughlin & Addison (1986) found that winter hair loss was only present in moose with winter tick infestations. This positive correlation between hair loss and total number of adult ticks showed that winter ticks could have a negative impact on moose wellbeing. This study did not delve into the consequences of this hair loss and its potential contribution to moose health decline. There were multiple studies that took up this challenge. Samuel concluded that winter tick infested moose groom more frequently and longer, resulting in a premature loss of winter hair (1991). This hair loss could contribute to decreased fitness, especially in calves, and hinder their ability to withstand cold temperatures in winter (Addison, et al, 1994). Besides loss of winter hair, it was found that winter tick presence reduced respiratory minute volumes and respiration rates of heat-stressed moose (Welch, et al, 1990). This same study found no effect on fasting metabolic rate or weight changes, which does not correlate with the earlier observations of weakened moose as a result of infestation. Two following studies conducted by the same team also have somewhat inconclusive conclusions in terms of the direct impact of winter ticks on moose. In 1994, Addison, McLaughlin & Broadfoot published an article stating that

heavy winter tick infestation in the fall may limit calf growth and physical fitness, which could lead to a reduced likelihood of survival in winter. The researchers also found that, after performing manual infestation of winter tick and blood testing, while ticks could impact blood characteristics of moose, “there was significant variation in these blood parameters (packed cell volume, gamma-globulin, lactate dehydrogenase) in relation to the level of tick infestation and activity of ticks, the magnitude of the tick effect was small” (Addison, et al, 1998: 189).

Blood testing is a valuable approach to studying how winter ticks could be impacting moose. A thesis done in 2011 suggested that winter ticks could cause “substantial protein and blood loss and presumably acute anemia when energy and protein are deficient in the diet” in calves and lower productivity possibly related to “reduce physical and nutritional condition of adult cows” caused by winter ticks (Jones, 2011: xi). This same study also noted that iron levels were lower in moose populations with winter tick infestation compared to populations without winter ticks. A study by Baldrige et. al. (2009) found that the bacteria *Anaplasma* (some species cause anaplasmosis) was present in winter ticks and could be passed from parent to offspring. While the study did not present evidence that winter ticks could transmit anaplasmosis disease to their host, there is a possibility that they could (Baldrige, et al, 2009). Another study investigating vector-borne pathogens in moose tested for both bacterial and parasitic pathogens in 615 moose (Malmsten, et al, 2018). The researchers found that “Anaplasma (82%), Borrelia (3%), Babesia (3%), and Bartonella (1%) DNA was found, showing that moose are exposed to, and can act as hosts of some of these pathogens” (Malmsten, et al, 2018: 1). This study concluded that moose can carry multiple pathogens

and could act as vectors of disease. More research is needed to explore the possible role between disease transmission and winter ticks on moose.

While most of the research done surrounding winter ticks was related to their direct impact on moose, multiple studies suggest that winter ticks are just one part of the issue and that extrinsic factors may have a bigger role than people think in the moose-winter tick relationship. In 1999, Pybus performed deceased moose inspections and looked at occurrence reports to conclude that most moose and calf mortality happened in late winter and that weather was the ultimate force driving interactions between winter ticks and moose. There was also a study that stated that extrinsic influences including weather, vegetation, and host played a role in winter tick infestation (Samuel, 2007). These biophysical factors could be independent of moose density, and warm and/or short winters could increase survival of adult female ticks leading to an increased tick population the following year (Samuel, 2007). The conclusions from multiple studies (Fenstermacher & Jellison, 1933; Peterson, 1955; Welch, et al, 1990) presented inconclusive findings related to winter tick impact on moose health and mortality, as well as the concept that weather could be playing a role in increased winter tick infestation as well as increased moose mortality.

While there have not been many studies that explore how winter ticks are directly affecting moose (Welch, et al, 1990; Addison, et al, 1994; Addison, et al, 1998), there have been multiple different publications that focus on winter tick ecology and the spatial relationship between moose and winter ticks. A publication from 1967 stated that winter tick distribution is impacted by temperature, aspect, slope, and vegetation (Wilkinson). Wilkinson also wrote that since the winter ticks exhibit larval activity in the winter and



egg development in the summer, they can move much farther north than other species. This specific winter larval activity contributes to moose infestation, especially since larvae are searching for moose hosts during moose breeding season when individuals are more active (Drew & Samuel, 1985). The dynamic of this larval activity means that moose movement helps to distribute winter ticks throughout the state (Zarnke, et al, 1990). The same study states that moose density also plays a role: when there are more moose interacting with each other, there is a higher chance for winter ticks to infest new hosts and travel with these hosts to different ranges.

While multiple studies portray winter ticks as an unstoppable force and moose as powerless victims, a study by Samuel, Mooring, & Aalangdong done in 2000 highlighted the adaptations that moose have developed in order to avoid winter tick infestation. According to Samuel et. al., moose have adapted to evade vegetation that could harbor winter tick larvae, tolerate magpies that eat ticks, and groom themselves to remove ticks (2000). The study also found that winter ticks have adapted to infest moose by aggregating on vegetation at height of moose when searching for a host. Winter ticks ascend vegetation to a height close to that of most moose torsos, generally 50-190cm above ground (McPherson, et al, 2000). This study by McPherson et. al. simulated vegetation to ungulate transmission using nylon rods as vegetation (2000). While winter ticks were limited by vegetation height, the tick clump size and height of ascension did not correlate with weather conditions. McPherson et. al. concluded that “larvae appear to determine their height above ground in the absence of external cues, but this mechanism may be modified by external conditions” (2000). While external conditions like temperature and precipitation (2002) may play a factor in how winter tick larvae search

for hosts, they have adapted to ascend vegetation to a height where they will likely come into contact with moose (McPherson, et al, 2000).

A more recent study done in 2014 by Musante et. al. found that while winter ticks prefer moose hosts, they can also be found on feral swine. This research was done in New Hampshire and has implications for winter tick dynamics in Maine. These feral swine could carry winter ticks into new areas, thereby expanding their range and exposing them to wildlife that would otherwise not be interacting with winter ticks. Musante et al. did not collect data on actual rates of infestation or number of feral swine that could be moving winter ticks into new ranges (2014). Determining tick density on moose, possibly through hide quadrant counts (Welch & Samuel, 1989), will be essential in determining if winter tick density is increasing on individuals and into new ranges in Maine.

#### Human Dimensions of Biodiversity Conservation and Wildlife Disease

Studying the human dimensions of conservation is very important because it allows managers to understand the values and perceptions of the public (Filion, 1980). More and more the public wants to be involved with natural resource decision making (Bath, 1998) and because of this, it is important to know what their values are and how their perspectives could influence species and ecosystem management to attain conservation objectives. Mitchell (1989) provides a framework for human dimensions that compares perspectives to spatial and temporal scales. The perspectives included in this framework include biophysical, economic, social, political, legal, institutional, and technological variables (Mitchell, 1989). Further, studying the human dimensions of wildlife disease in particular is important because, as Vaske puts it, “human dimension

research is essential for wildlife management and understanding the societal consequences of wildlife diseases” (2010: 166), and potential impacts on wildlife management with biodiversity conservation in mind. Wildlife disease can impact human health, conservation efforts, recreation behavior, cultural identity, and the economy among other things; hence, human dimensions research can aid managers in understanding how people’s perceptions influence these sectors of society in relation to wildlife disease.

The study of risk is an area that has gained relevance as we seek to better understand the human dimensions of biodiversity conservation and wildlife disease. Risk perceptions are defined by Needham & Vaske as the “extent to which individuals believe that they are or may be exposed to a hazard” (2008). Risk perceptions play a big role in how people understand an issue and how these perceptions might influence their behaviors and decision making processes. There have been multiple studies and publications about wildlife disease risk perceptions that can shed light into the factors that influence perceptions and action (Vaske, 2010; Needham & Vaske, 2008; Oruganti, et al, 2018). A framework for human dimensions of wildlife disease presented by Vaske et. al. (2009) includes the following constructs: perception of risk, information sources and knowledge, trust in wildlife agencies, acceptance of management, stakeholders, and economic impacts. Stakeholders are considered to be people with an interest or concern on an issue. Needham and Vaske published a study that addressed the relationship between risk perceptions of wildlife disease and trust in management agencies (2008). They found that in relation to Chronic Wasting Disease (CWD), hunters perceived less risk from CWD if they had higher trust in wildlife management agencies (2008).

In a wildlife disease management model presented by Decker, et. al., risk is categorized into objective risk, risk perception, and risk education/communication (Decker, et al, 2006). While objective risk relates to scientifically derived risk from wildlife disease, risk perception and risk communication are centered around how stakeholders learn about risk and how severe they perceive a disease risk to be. These perceptions are important to study in order to help wildlife managers develop “communication messages that enhance public understanding of wildlife disease risks and that aim to increase public support for disease management” (Hanisch-Kirkbride, et al, 2013: 841). Human dimensions research can contribute to effective wildlife management and will be an essential part of understanding how the public perceives the direct and indirect impacts of winter ticks on moose and their effects on Maine’s cultural, natural, social and economic resources.

### Results Organized by Data Generation Technique

The following results were generated using multiple analytical tools in NVivo, such as word frequency, word tree, and text search queries. The qualitative data analysis of interviews, archival evidence, and questionnaire responses using NVivo 12 Plus resulted in five major emergent topics. Listed in order of the most referenced, the topics were: determinants of moose health, moose and outdoor recreation opportunities, moose’s role in maintaining cultural identity, perceptions on winter ticks and disease transmission, and moose health and economic vitality. The analysis of the data allowed me to visualize the connections between these topics of interest and perceptions of moose-winter tick-human system interactions. The first section of this chapter presents

key results of word frequency queries ran to identify the most common terms organized by data generation technique. The second section includes a summary of emergent patterns from the interview data and integrates a brief comparison of codes across multiple data generation techniques.

### Interview Results

A word frequency query allowed me to see what words were mostly used by study participants. Table 4 provides a summary of the top five most frequent words: “moose” and “winter ticks” are the most mentioned words for all stakeholders interviewed. The words “people” and “indigenous people” also came up significantly in the frequency search (Table 4). Using a text search query, I was able to associate some of the most frequent words with the most common preceding words—the terms mostly used prior to the word of interest (i.e. moose, winter ticks, people, etc.). While “population” was high in the word frequency, a query revealed that “moose population” was what was really being referenced to by study participants. This same method solidified that the word “tick” was really in reference to “winter tick.” These word frequencies highlight some of the key aspects of the moose-winter tick-human relationship: moose, winter ticks, and people. They also set the stage for some of the important topics that emerged in the analysis related to hunting and moose populations.

Table 5. Word frequency for all Stakeholder Groups Combined and by Individual Stakeholder Groups

Top words by frequency	Combined stakeholders	Outfitters	Wildlife managers	Wabanaki citizens
1	<b>Moose</b>	<b>Moose</b>	<b>Moose</b>	<b>Moose</b>
2	<b>Winter Ticks</b>	<b>Winter Ticks</b>	<b>Winter Ticks</b>	<b>Winter Ticks</b>
3	People	People	People	Indigenous People
4	Hunting	In Maine	Moose Population	Hunting
5	Moose population	Moose population	Hunting	Outdoors

This table tells us that people are concerned about the dynamics between moose populations, winter ticks, and people. While wildlife managers and Wabanaki citizens both referenced hunting, outfitters mentioned more frequently the term “in Maine.” This suggests that Wabanaki and wildlife managers are focused on the role of hunting in the moose-winter tick-human relationship, while outfitters might be more concerned about how this relationship could impact different social or economic dynamics Maine. The phrase “in Maine” suggests that these stakeholders were thinking about the big picture of how the moose-winter tick dynamic could impact the State of Maine as a whole. Wabanaki citizens referenced indigenous people, which highlights their focus on the relationship of indigenous people to moose and winter ticks. Wabanaki citizens also focused on the outdoors, which could be related to close connection with the natural resource base.

Determinants of Moose Health. Moose health was by far the most referenced topic in the interview data. A common topic within moose health was moose population health and individual moose health. The coding hierarchy (Fig 1.) for moose health shows that people perceived winter ticks as mainly impacting calves and being an important contributing factor to moose mortality. As mentioned by study participants, the perceived physical impacts that winter ticks have on moose include blood loss, hair loss, and moose mortality. These perceptions are similar to the conclusions drawn by research cited in the literature review (Welch, et al, 1990; Addison, et al, 1994; Samuel, 1991). Addison et. al. wrote that winter tick infestation could “predispose calves to reduced physical fitness and likelihood of survival during winter” (1994: 1), a common idea shared by stakeholders.

Moose population health was a big part of the conversation about moose health in general. Moose density was an idea mentioned throughout the data that highlighted the common perception that winter ticks have increased as a result of moose densities increasing. One statement highlighted this saying moose can have “social issues, behavioral issues...they're solitary animals. They keep coming into contact which is what spreads the parasites and diseases that also contribute stressors” (Interview with middle-aged outfitter, June 28, 2018). When looking at moose population stability, the majority of stakeholders said they believed it was in decline while a few said they believed it was stable. There seemed to be two perceptions associated with a declining moose population: that a reduction in moose density would be beneficial to the overall population “there may be fewer moose in some areas but that may be okay because fewer moose may mean less hosts for ticks to get on and we may see things stabilize” (Interview with middle-aged Wabanaki citizen, August 9, 2018) or that this decline could mean the end of moose

in Maine “if it keeps going how it is I would guess there won’t be any moose I can imagine them being gone” (Interview with senior Outfitter, October 13, 2018).

Another common idea that emerged was that there is a lot of regional variability within the State of Maine and that habitat change could be playing a role in moose population change, as well as winter tick infestation rates. Habitat change may lead to range changes for both species, which could also impact infestation rates and moose health. It is clear that people are concerned about moose health and the impact that winter ticks could be having on moose. While participants mentioned other factors that could be impacting moose health, such as weather and moose density, winter ticks were almost always a part of the conversation.

The following figure (Fig 1.) presents the main ideas associated with moose health as mentioned by interviewees. These ideas have been categorized into relevant subcategories and are organized by coding hierarchy. The larger the square, the more often the idea was mentioned. In Fig 1., the overarching idea is moose health. Moose population health is the biggest subcategory followed by winter ticks as a contributing factor to moose mortality. The figure presents what stakeholders thought about when considering the determinants of moose health and which ideas were more commonly shared. While there are a lot of ideas included in the figure, the hierarchy allows us to observe which ideas were more prevalent to the stakeholders, like moose population health and winter ticks as a contributing factor to moose mortality.



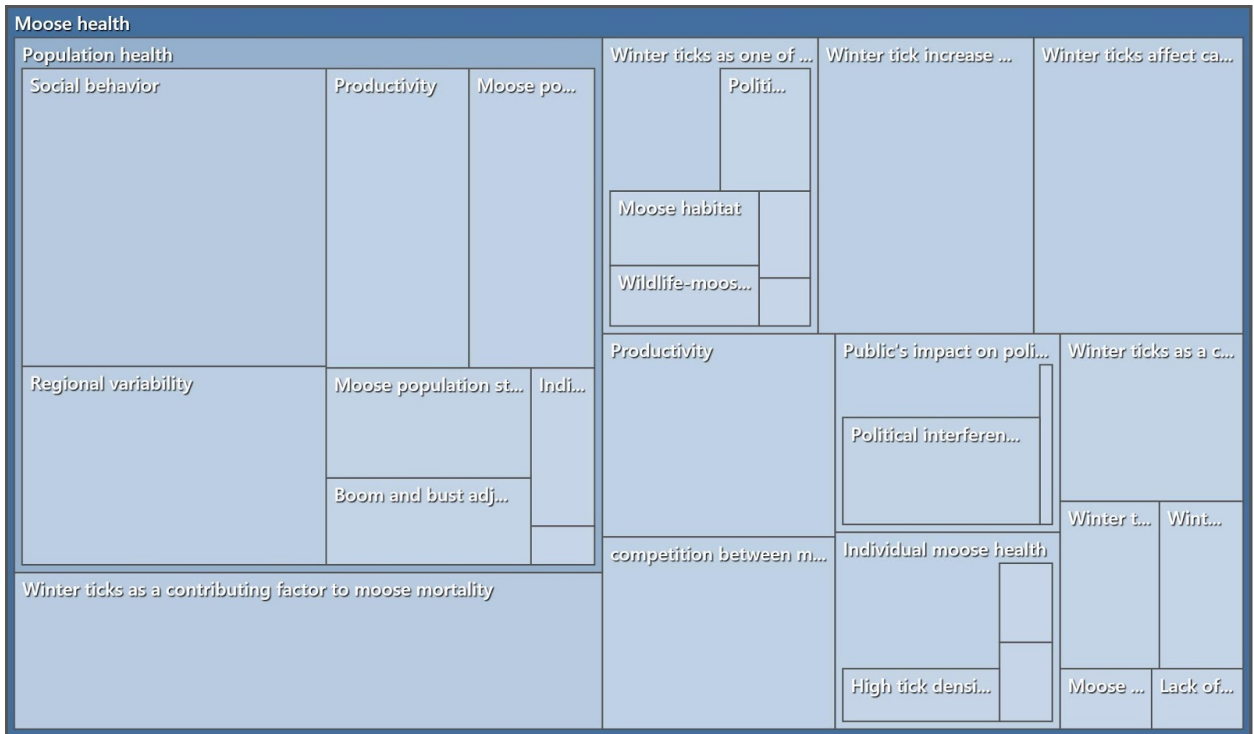


Fig. 1. Coding References for Moose Health

Moose and Outdoor Recreation Opportunities. Moose population health is directly connected to recreation opportunities in Maine. When it comes to perceptions of recreation, two main ideas emerged: hunting and tourism appeal. The strongest connection to recreation opportunity was hunting. Moose hunting permits were a key aspect of hunting as a code, including perceptions that winter ticks contribute to decreased hunting permits in the state. This is highlighted by multiple interview participants: “we have had a significant reduction in our moose population and in our hunting opportunities because of winter tick impacts to the moose population” (Interview with middle-aged wildlife manager, July 26, 2018), “it’s a direct ratio the more ticks the more mortality the more mortality the less hunters and maybe even less sightseers” (Interview with senior outfitter, July 18, 2018). A smaller connection that emerged was the idea that hunting was contributing to a decrease in the moose population: one

interviewee stated that “it’s hard to even imagine hunting a moose right now” (Interview with senior outfitter, October 13, 2018). In general, hunting was portrayed as a key recreation opportunity in Maine.

Moose are also perceived as a key part of Maine’s tourism appeal. Winter ticks were linked to moose viewing tourism through the idea that they were contributing to fewer moose being viewed. Another link to winter ticks and tourism was the negative impact that they could have on moose appearance: “I think we still have a lot of people that just want to look at and photograph moose...I’ve followed and watched some awful, awful looking moose and I don’t think anybody wants to see sick and unhealthy animals” (Interview with young Wabanaki citizen, August 9, 2018). While there were statements that winter ticks are making moose harder and harder to see, an almost equally strong viewpoint was that people are not seeing as many moose because they are expecting to see moose without trying. This concept is exemplified by the following quote: “you have to work a little harder...no matter where you are in Maine to see a moose these days just because of the habitat change, the winter tick had nothing to do with that.” These two contradictory ideas demonstrate the multiple perceptions, and the complexity of the construction of meanings that need to be considered when seeking to understand the moose-winter tick-human interactions.



Fig. 2. Coding References for Recreation Opportunity

When the coding for recreation opportunities was organized by interview classification, it became clear that outfitters were the most concerned about impacts to recreation (Fig. 3). Wildlife managers were somewhat concerned while Wabanaki citizens mentioned recreation opportunities the least. This could be because moose provide sustenance and are integrated into Wabanaki culture: this reliance is more personal than viewing moose hunting solely as a recreational opportunity. The following quote from an interview participant highlights the different viewpoint that Wabanaki citizens can have about moose: “hunting season is...all about moose it’s what’s way more important than deer or anything else that we do because it brings so much meat to the family and to the community and to the elders...the health of our nation is really part dependent on that meat because if we’ve got a lot of moose meat that’s in the community, that’s going around, they’re eating healthy meat, healthy food...the other part is you have

all the traditional kinds of things that you use moose for that's pretty important”  
(Interview with middle-aged Wabanaki citizen, October 1, 2018).

One of the most prevalent concerns associated with recreation was the idea that moose are part of Maine's tourism appeal and that a decline in moose population would reduce the moose viewing tourism and moose hunting tourism. This view was held by all of the interview participants. One stakeholder stated that “towns all over Northern Maine really depend on that moose hunt...I think you have people who just want to go up and see moose, and they pay money just to go see moose, I mean that's probably just as big too if not bigger than the moose hunting economy” (Interview with middle-aged Wabanaki citizen, October 1, 2018). Hunting and moose hunting permit reduction was a concern of all interview participants. Winter ticks were cited as being the cause of decreased moose permits by all stakeholder groups. Since the outfitters interviewed all relied on moose for their business, whether it be through moose hunting or the intrigue of moose viewing, it is not surprising that they were the most concerned about the potential impacts of winter ticks on moose populations and what this could mean for recreation opportunities in Maine.

While moose hunting and moose hunting permits were mentioned by all stakeholder groups, Figure 3 makes it clear that these topics were mentioned the most by outfitters, then wildlife managers, and finally Wabanaki citizens. The size of the colored bar indicates the number of coding references made about the topic, in the case of hunting permits and the economic impact of hunting, the bars are colored grey and tan respectively. Figure 3 also shows that when talking about recreation, Wabanaki citizens were more concerned about the tourism appeal of moose (lavender bar) than the other

topics related to recreation. In general, Wabanaki citizens had less to say about recreation as it relates to moose and winter ticks than wildlife managers or outfitters.

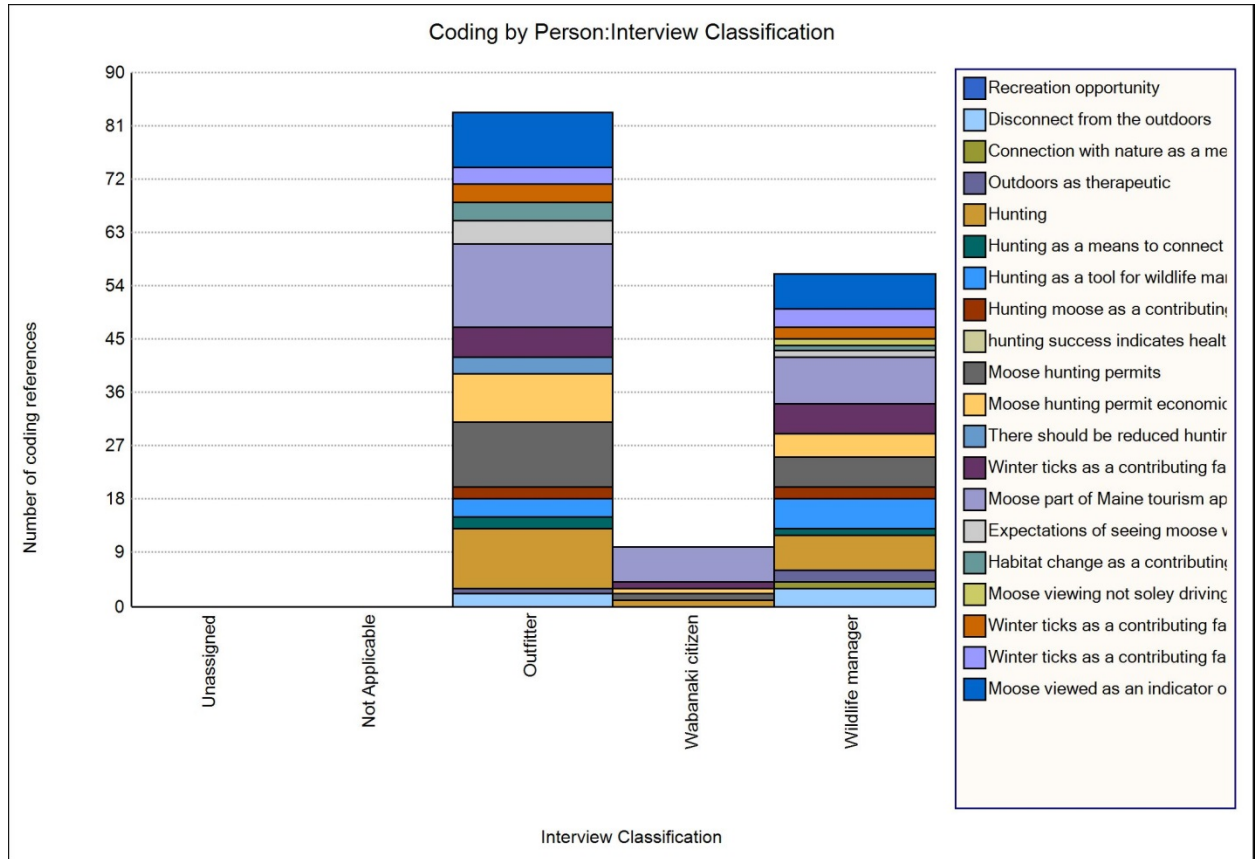


Fig. 3. Coding for Recreation Opportunity by Interview Classification

Moose’s Role in Maintaining Cultural Identity. There were two facets of cultural identity:

Maine culture and Wabanaki culture specifically. Within Maine culture related to moose, the major idea that emerged was hunting. The common viewpoint was that moose hunting is a component of Maine’s culture. One interview participant said “it’s just almost in our DNA we’re hard wired for that (hunting) up here” (Interview with senior outfitter, July 18, 2018). As was mentioned in the previous section, there was a concern that if winter ticks decrease the moose population, then the number of moose hunting

permits would decline, and this could impact Maine's culture through a loss of moose hunting traditions. This is important because the majority of the outfitters and Wabanaki citizens associated hunting with Maine culture. While one outfitter stated "Maine moose hunting is like a phenomenon and it's like a cultural thing" (Interview with senior outfitter, July 18, 2018), the concern about decreased hunting related to culture was much less frequently mentioned than it was related to recreation opportunity in the previous section. This could be because hunting is a form of recreation and the two are directly linked, while impacts to culture might be more indirect.

The relationship of moose to Wabanaki culture appears from the data to be very strong: moose play a central role in the culture and identity of its citizens. There were many references to creation stories involving moose and the connection that these stories had to culture. A significant part of the relationship between moose and Wabanaki people was sustenance hunting. Hunting moose is also integrated into Wabanaki culture as a rite of passage, which was presented in one of the interviews: "for young men it's a rite of passage...for young men when they shoot their first moose...they understand that their role is to be a provider and not to be a hoarder but to share" (Interview with middle-aged Wabanaki citizen, November 2, 2018). This quote outlines an example of just how meaningful moose are to Wabanaki citizens: it shows that moose play an important role in the development of young Wabanaki and is used to impart life lessons.

Moose provide sustenance and other valuable resources for Wabanaki people. One of these cultural resources that comes from moose is the use of moose hides for drums. This could be a cultural practice impacted by winter ticks as one interviewee states: "if we have a moose hide that has too many ticks on it then we don't use it"

(Interview with senior Wabanaki citizen, October 1, 2018). This is important because if winter ticks begin to infest moose more heavily, then there will be a greater chance that this tradition will be lost. Other traditional uses of moose are not necessarily as closely tied to winter tick impact as hide quality is, but if moose populations were to decline to a point where moose could no longer be hunted, Wabanaki citizens would lose other resources as well. One interviewee said that they “use the moose legs for fleshing hides, part of the sinew of the moose for sewing different things, and the moose hides for moccasins...the moose offers us so much culturally I just can’t imagine our culture not having moose” (Interview with middle-aged Wabanaki citizen, October 1, 2018). Not being able to make traditional crafts like drums or moccasins would mean that Wabanaki culture could lose some of its traditional knowledge and cultural practices. The dialogue surrounding the contributions of moose to Wabanaki culture, from traditional crafts to rites of passage, show that Wabanaki culture is highly connected to moose.

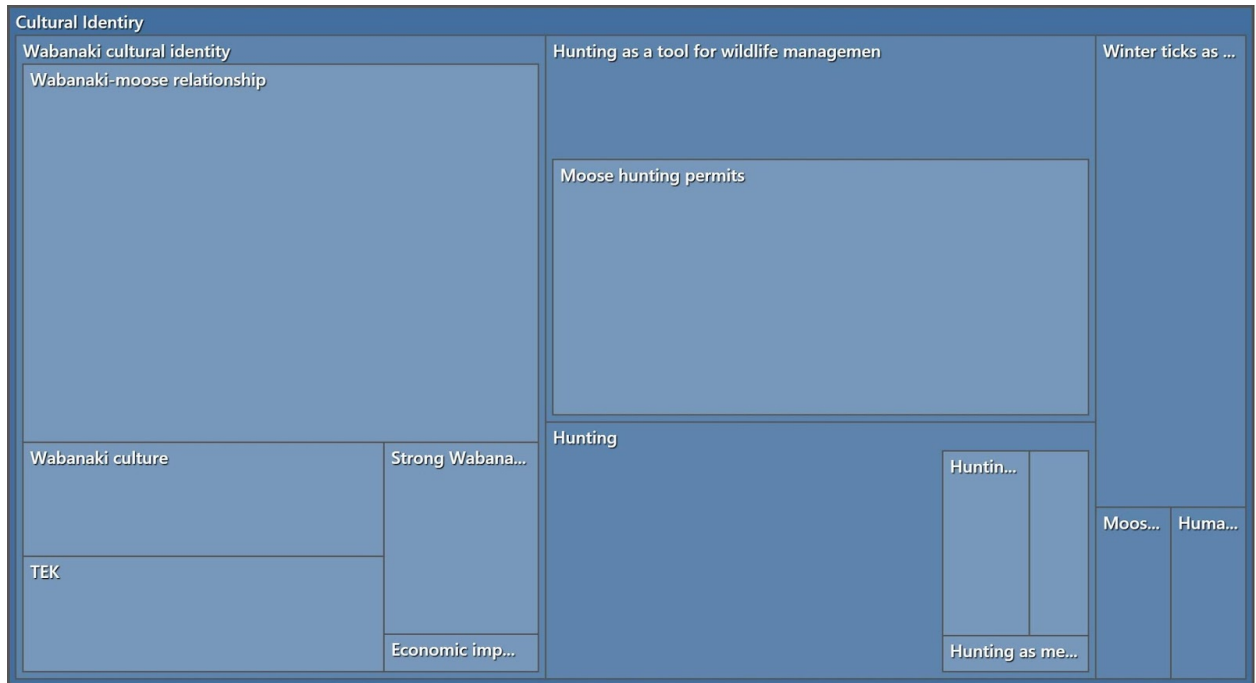


Fig. 4. Coding References for Cultural Identity

The following graph (Fig. 5) depicts the different topics mentioned by the different stakeholder groups in relation to cultural identity. The graph shows that Wabanaki citizens generally had more to say about cultural identity than the other two groups did. The purple bar present in the Wabanaki citizen column suggests that Wabanaki stakeholders considered moose to be tied to a strong and healthy Wabanaki community. Sustenance hunting and moose hunting as part of Wabanaki traditions were key topics that Wabanaki citizens related to cultural identity. As one interviewee put it, “the reason why we’re hunting moose is to have a very healthy protein source and as well as our traditions and helping to feed our families” (Interview with middle-aged Wabanaki citizen, November 2, 2018). The relationship of Wabanaki culture to the tradition of moose hunting was very strong and the Wabanaki stakeholders focused on sustenance hunting as one of the practices that could be impacted by a decline in moose health. This



further demonstrates the different perceptions of outdoor recreation: for Wabanaki citizens hunting moose is about culture, sustenance, and community while for other stakeholders it is about recreation and the culture of hunting for leisure.

For wildlife managers and outfitters, cultural identity was strongly related to hunting and stakeholders were concerned about how winter tick impacts could limit moose hunting permits. Hunting was also mentioned as a tool for wildlife management by both of these groups, more so by wildlife managers. Cultural identity is tied to the ability to hunt in association with the culture of outdoor recreation, which all of the stakeholders believed could be diminished by the impacts of winter ticks on moose population health.

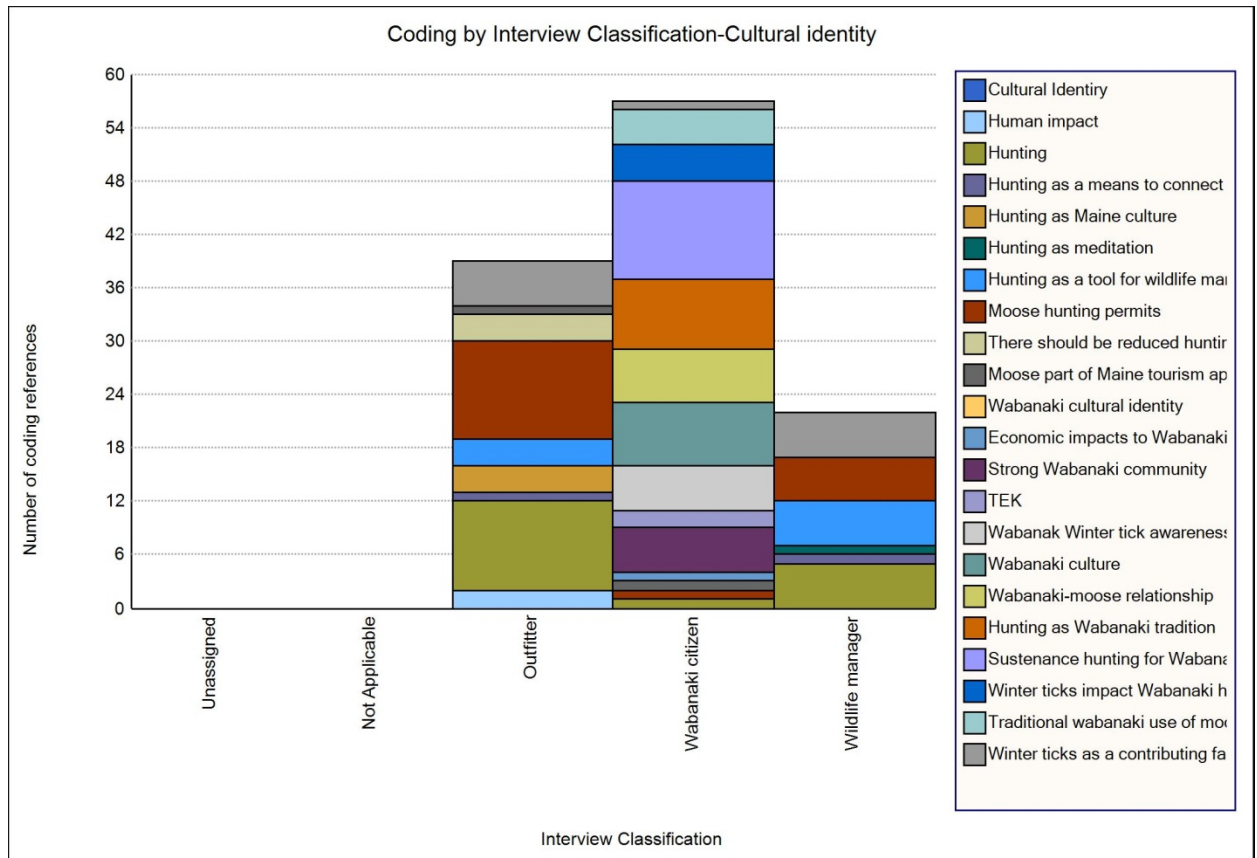


Fig. 5. Coding for Cultural Identity organized by Interview Classification

Perceptions on Winter Ticks and Disease Transmission. The topic of winter tick perceptions was hard to analyze, there was no clear key topic associated with the knowledge and awareness of winter ticks. When it comes to the perception of winter tick impact, the most prevalent topic was the idea that winter ticks are devastating the moose population. At the same time, there was the perception that winter ticks have always been present on moose in Maine. It also became clear that people believed hunters are the most likely to interact with winter ticks, and therefore are more likely to be aware of their existence and potential impact on moose. When it comes to the topic of general awareness of winter ticks, there was a perception presented by all stakeholder groups that the general public does not have a strong understanding of what winter ticks are and how they are impacting moose. There was a viewpoint held by wildlife managers that suggested that people without much knowledge of winter ticks believe they are doing much more damage to moose than they are in reality. Along with the perception that the general public has a limited understanding of winter tick impact, there was also the idea that winter ticks are unknown to many people and that there is a common misconception that they are just a tick in the winter. This idea that the public believes that winter ticks are just ticks in the winter, or that all ticks are the same, was held by all stakeholder groups.

When looking at the perceptions of what demographic of people are the most likely to know about winter ticks and interact with them, there was a consensus between all stakeholder groups that hunters are more likely to have an awareness and understanding of winter ticks. One interview participant said that “for moose hunters I think there is awareness but in general I think there’s not in-depth knowledge about the

life cycle of a winter tick and that its primary mammal host is a moose” (Interview with middle-aged Wabanaki citizen, November 2, 2018). It is logical that hunters, especially moose hunters, would be more aware of winter ticks since they rely on healthy animals and winter ticks could be impacting the animals that hunters are bringing in. Since moose population numbers directly influence hunting permits and the ability to hunt, hunters are probably more likely to be aware of any potential threats to moose.

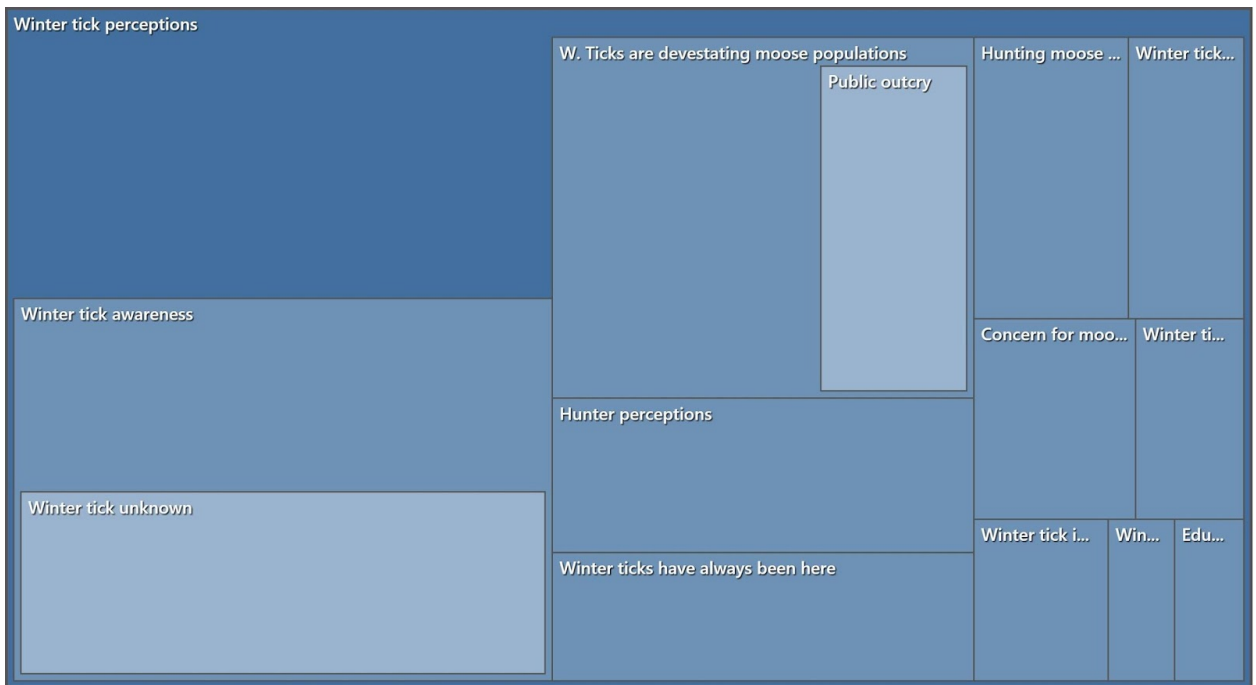


Fig. 6. Coding References for Winter Tick Perceptions

When looking at the views of disease transmission, disease was quickly linked to ticks other than winter ticks. While people were concerned about tick borne diseases related to other ticks, perceptions about winter ticks as a vector of disease were divided into three categories: the idea that there was a possibility they could transmit disease (“I think it’s possible...but I’m not aware of any kinds of transmission that comes from

winter ticks yet” (Interview with middle-aged Wabanaki citizen, November 2, 2018)), that there was no knowledge that they could transmit disease (“we haven't found winter ticks to carry any vector borne disease” (Interview with senior wildlife manager, June 19, 2018)), and that winter ticks do not pose any threat to humans (“the winter tick isn't one that hosts off of humans” (Interview with middle-aged outfitter, June 28, 2018)). The last of these views relates back to human health and the perception that winter ticks are not a threat to people. The first two relate to moose health; there were no opinions that contradicted the idea that there is a possibility for disease transmission from winter ticks to moose: “without a doubt disease transmission is a possibility” (Interview with middle-aged outfitter, June 28, 2018).

Disease transmission		
Tick borne disease	Possibility of disease transmission	Winter ticks don't pose a th...
	No knowledge of disease	

Fig. 7. Coding References for Disease Transmission

When looking at opinions about human health related to the moose-winter tick relationship, it became clear that when people hear the word “tick,” they associate it with tick borne disease. When it came to human health, tick borne disease was the main topic. There was the perception that there is a general fear of tick-borne diseases and that this fear often leads to an avoidance of the outdoors. There was a common perception by wildlife manager and outfitters that winter ticks don’t pose any threat to humans: “from everything I’ve read and heard about that they really don’t bite or feed on humans commonly at all” (Interview with young wildlife manager, July 25, 2018), “winter ticks don’t bother people” (Interview with senior wildlife manager, June 19, 2018). The idea that winter ticks don’t pose any threat to humans was not mentioned by Wabanaki citizens, instead this stakeholder group perceived that if there is a possibility of disease transmission, then winter ticks could transfer disease to humans: “I think the transference of concern about Lyme disease from deer ticks gives us pause to think about oh is there potential that there’s this transference of disease to me” (Interview with middle-aged Wabanaki citizen, November 2, 2018). There was a reoccurring understanding presented by wildlife managers and Wabanaki citizens that moose are really the only host for winter ticks. There was little to no mention of winter ticks as host specific by outfitters.

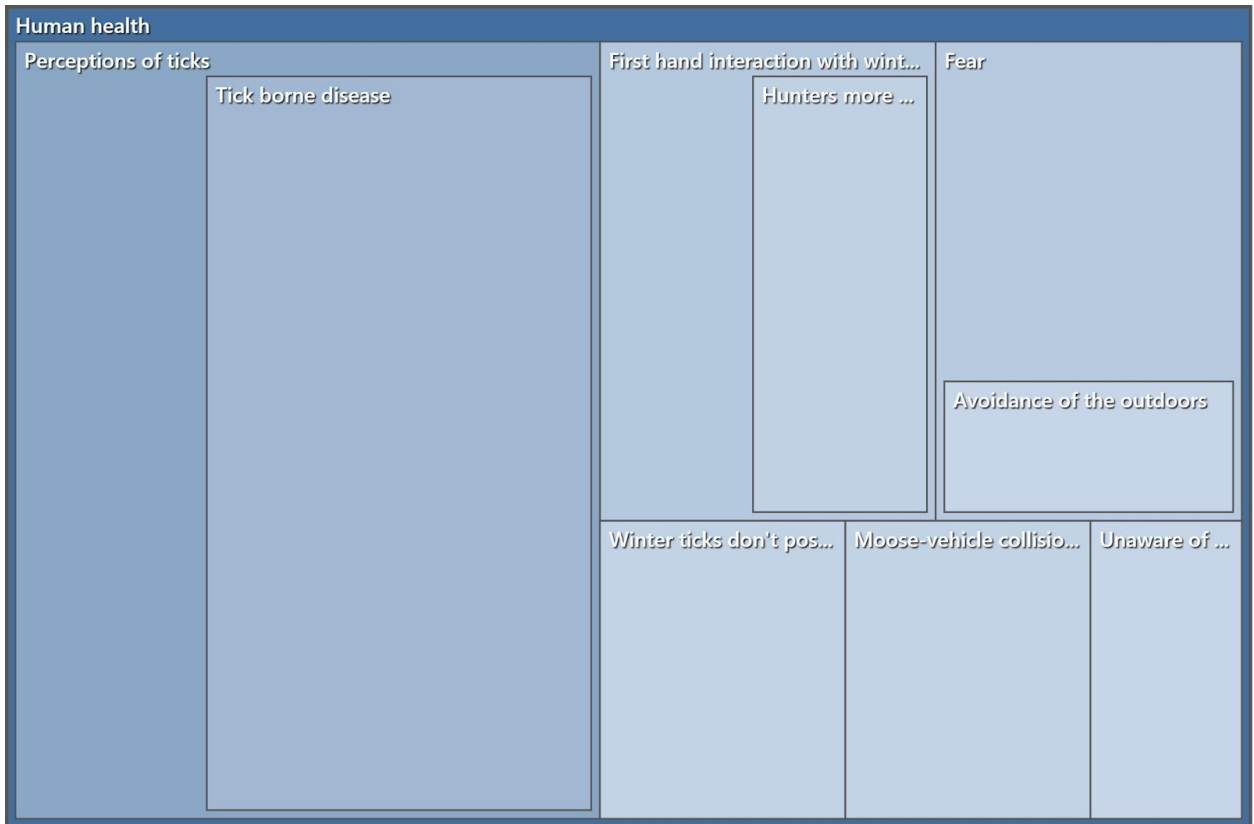


Fig. 8. Coding References for Human Health

Moose Health and Economic Vitality. There was only one main idea related to Maine’s economic vitality: the relationship of moose to tourism. The idea that moose are a large part of Maine’s tourism appeal and tourism economy was highly prevalent. All stakeholder groups mentioned the relationship of moose to tourism and the economic impacts that this tourism can have. All groups also highlighted moose hunting tourism as a contributor to economic vitality: “a lot of people who hunt moose in the state, particularly folks who come in from out of state, hire registered guides, they stay in lodges...even if they’re not hiring a guide most people take a week’s vacation, they go up to stay at camp. When they’re done moose hunting they might go bird hunting and spend lots of money in the local restaurants, grocery stores, gas stations” (Interview with middle-aged wildlife manager, July 26, 2018). This quote highlights the indirect impacts

that moose tourism, especially hunting tourism, can have in terms of money going into Maine's communities. This hunting tourism relies on permit numbers to give people the opportunity to hunt moose. Regarding the economic impact of less moose permits, one interviewee said "if I had to put a number on it I would say that there are five or six less hunters that we've been able to guide which equates to a retail \$1500 dollars' worth of business. Five hunters, \$3000, that's a pretty good number. About \$1500 dollars a year less business in the last ten years because of the lack of population to support more hunting" (Interview with senior outfitter, July 18, 2018). This quote is very powerful because it shows that this outfitter perceived direct economic loss due to decreased moose hunting permits. Moose hunting permits were seen as major contributors to the economy of the state, whether they be purchased by out of state tourists or domestic hunters. The moose tourism economy, through hunting and moose viewing, was presented as being very important by all participants.

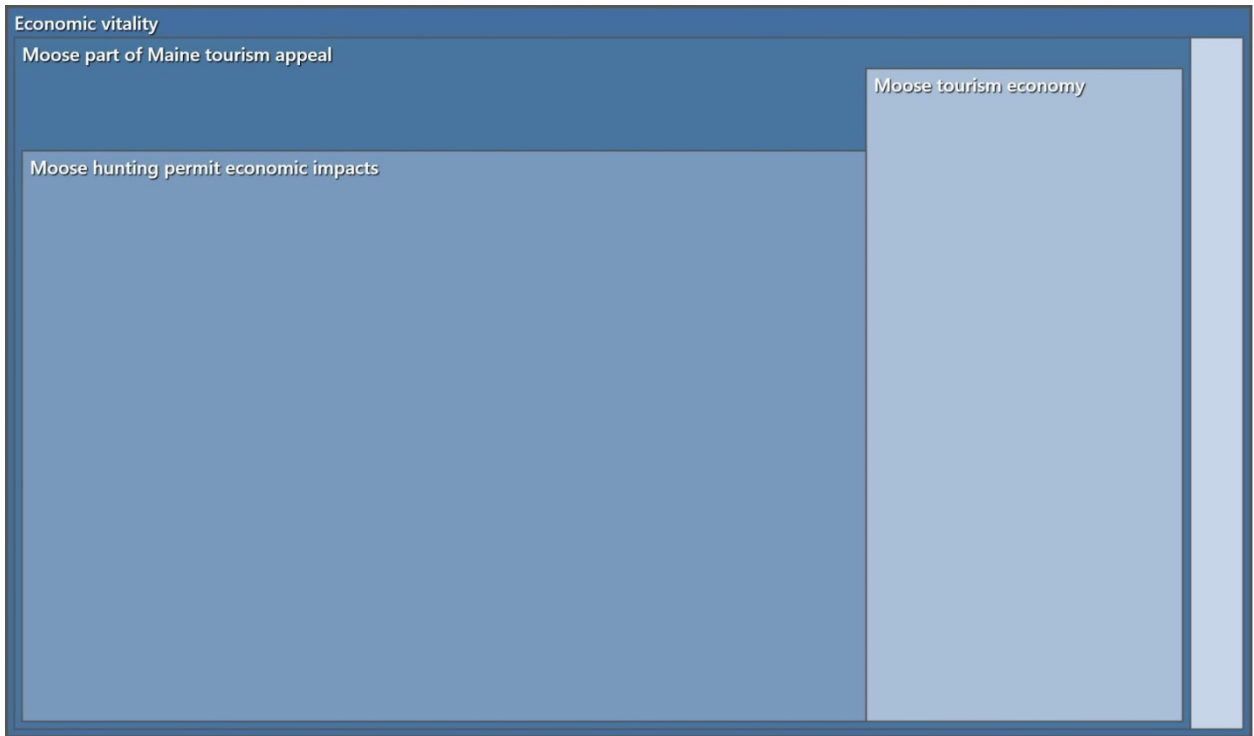


Fig. 9. Coding References for Economic Vitality

### Questionnaire Results

The following results come from four opened ended questions that were posed to Wabanaki citizens distributed as part of a questionnaire concerning ticks, winter ticks, and moose. A baseline word frequency query showed that the common terms found throughout all four questions were moose, ticks, population, and disease. Other notable words included family, healthy, winter, hunting, sustenance, food, meat, and animals. This frequency is not surprising considering the questions focused on the impacts of winter ticks and the potential impact of moose decline on individuals and culture. For each individual question, the responses were coded using word relevance and a word hierarchy was generated in order to visualize prominent topics.

The responses to the question “In your opinion, what are the greatest threats from an increase in the tick population on tribal lands?” clearly show that respondents were



very concerned about human disease, as well as impacts to wildlife, especially moose. Some of the responses include “Lyme disease” (Questionnaire participant, 2018), “people and animals contracting diseases” (Questionnaire participant, 2018), and “the greatest threat are a decrease in animals that provide our people with sustenance and the overall health of animal populations...we should be very concerned” (Questionnaire participant, 2018). To a lesser degree there was mention of the threat of decreased ability to enjoy the outdoors due to tick presence and disease potential: “loss of comfortable enjoyment of our lands” (Questionnaire participant, 2018).

All participants who answered that they had heard of winter ticks in a previous question were asked specifically “In your opinion, what is a winter tick?” A small portion of answers referenced winter ticks as a species of tick and only slightly more connected them to their alternate name of “moose tick”. The two major topics that emerged as definitions of winter ticks were ticks in the winter, “ticks that are out and about in the winter” (Questionnaire participant, 2018), or ticks that are on moose, “ticks often found on moose” (Questionnaire participant, 2018). Other answers were vague but almost all of them held a negative connotation toward winter ticks: “a spawn of Satan” (Questionnaire participant, 2018).

When asked about “In your opinion, what does it mean for a moose population to be healthy?”, there was a more diverse set of answers and a wider range of ideas. The three most common conceptions about a healthy population were that there was no disease, that the population was not overpopulated, and that individuals are not competing too much for resources. Some of the responses to the question include “disease free” (Questionnaire participant, 2018), “sustain a healthy population that

correlates to the food and habitat available in the State of Maine” (Questionnaire participant, 2018), and “healthy populations mean there is no overpopulation” (Questionnaire participant, 2018). Other emerging thoughts included a healthy environment, continued moose breeding, and less ticks. A benchmark for a healthy population that was noted was being able to hunt moose.

In response to being asked “What would be some of the impacts to you personally in response to a decline in the moose population?”, which was only posed to participants who responded that a decline would pose a "serious" or "very serious" threat to them personally, the perceptions were much more homogeneous. The most prevalent idea was the loss of an important food source from not being able to hunt moose. There was also a concern presented in the questionnaire about a decreased ability to hunt and a loss of traditional culture, as well as negative impact to ecosystems from a loss of such an iconic species: the moose. One response stated a population decline “would indicate an imbalance within the environment which impacts all of us” (Questionnaire participant, 2018). A smaller consensus level—more varied and distinct responses—occurred with the topic of decreased ability to see moose and the detrimental impact this could have on tourism. This was stated as one of the impacts of a decline in moose population by one of the questionnaire participants: “decrease in the majestic animal being seen in Maine would be detrimental to many people and tourism” (Questionnaire participant, 2018). Less moose could decrease the demand for moose viewing tourism opportunities and bring less people to Maine for the purpose of seeing a moose.



related to moose and winter ticks. Figures 11 and 12 present word clouds for the interview and questionnaire data respectively. The larger the word in the cloud (i.e., the more frequently mentioned in the data). Comparing between all three of these figures, it is easy to see that moose are the center of attention and winter ticks are closely involved. Winter ticks seem to be mentioned almost as much as moose in the interview data, but less so in the newspaper articles and even less in the questionnaire. Using a text search query, I was able to determine that when the word “moose” is mentioned it frequently in the context of “moose population.” This suggests that the majority of risk perceptions related to moose are concerned with the population levels and effects that winter ticks could have on the population as a whole, not just the health of individual moose.

The interview data in Fig. 11 indicates that the words “people” and “hunting” were more specific to the interviews. This could be due to the fact that the interview questions asked directly about hunting while the other sources did not. The questionnaire word cloud (Fig. 12) suggests that “disease”, “animals”, “food”, and “meat” were unique to the questionnaire data. This makes sense since these data came from Penobscot citizens who rely on moose hunting for sustenance. This topic of sustenance hunting of moose, especially as part of Wabanaki culture, was presented earlier and is supported by the results of both the interviews and the questionnaire.



showed that the words “hunting,” “permits,” “see,” and “healthy” were the most frequently mentioned in association with moose populations. Moose hunting and viewing are both reliant on healthy moose. These recreational opportunities are perceived to be the things that would be most impacted by a reduction in moose populations due to winter ticks.

Another pattern was the mention of Lyme disease and deer tick risks. When looking at the word “disease,” a word search query found that the word “Lyme” was the most frequently associated with it. This suggests that when people think of ticks and diseases, they commonly reference Lyme disease and deer ticks. When asked about how winter ticks could impact human health in the interviews (Fig. 6), the trend suggested people did not believe winter ticks pose a threat to humans but that they were worried about Lyme disease and believed there was a possibility that winter ticks could be acting as vectors of disease to moose. When asked if winter ticks could be acting as vectors for disease transmission one interviewee replied: “without a doubt disease transmission is a possibility” (Interview with middle-aged outfitter, June 28, 2018).

The questionnaire data mirrors these perceptions. When looking at the answer to the question “In your opinion, what are the greatest threats from an increase in the tick population on tribal lands?” the most prevalent answer was either Lyme disease or, more generally, the concept of diseases spreading to individuals through ticks. When it comes to tick borne disease, people seemed much more likely to reference Lyme disease than the possibility of winter ticks transmitting diseases to moose.

These two emerging patterns suggest that people are concerned about how winter ticks could be impacting moose health in relation to moose dependent activities like

hunting and moose viewing. When looking at the main topics across data sources, “moose” and “ticks” were the most frequently mentioned words in the newspaper articles, questionnaire, and interview data. This concurrence of topics contributes to the validity of the emerging patterns in this study. These activities contribute to the culture of Maine as well as tourism in the state which impacts Maine’s economy. Data on people’s associations with ticks in general shows that people are nervous about Lyme disease and other tick-borne illnesses. Fig. 4 illustrates the concept that people may not know much about winter ticks, including the fact that they are a specific species of tick. This is supported by the questionnaire question that asked “In your opinion, what is a winter tick?” which was answered by the majority (25 out of 41 answers) in a way that didn’t suggest winter ticks were a specific species. Many answers cited winter ticks as “a tick that survives winter” or “tick that are on moose.” The data from these two sources indicates that there might be a lack of knowledge about winter ticks and the way they interact with moose including their lifecycle and host specificity. More research is needed to determine what people know about winter ticks as a species and how people are learning about winter ticks.

## CHAPTER 5: CONCLUSION

### Key Ideas Learned

The emerging topics established through this research suggest that stakeholders (hunters, outfitters, wildlife manager, Wabanaki citizens) and concerned about the impacts of winter ticks on moose. Key components of the perceptions that were presented through the interviews, questionnaire, literature review, and newspaper article review included concerns that a decline in moose health and moose populations could reduce hunting and moose viewing opportunities, which in turn 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.

In addition to culture of hunting and outdoor recreation in Maine, Wabanaki citizens expressed concerns about how a decrease in healthy moose could impact their culture and sustenance hunting practices. Moose play an important role in Penobscot legends and are a big part of traditional Wabanaki practices (Prins & McBride, 2007). Wabanaki stakeholders were concerned that not only would a loss of moose remove an integral source of food, but it would also indicate the loss of a cultural icon.

One of the final key ideas established through this study was the perception that while winter ticks don't pose a threat to humans, they could potentially be acting as vectors of disease to moose. The data suggests that most people were open to the idea that winter ticks could be transmitting diseases to moose. When looking at the data, especially from the questionnaire, an emerging topic related to winter ticks was the idea that not many



people know what winter ticks are. If people have limited knowledge of winter ticks as a species, their perceptions on the possible impacts of winter ticks on moose might differ from those of individuals with more knowledge about winter ticks.

### Limitations and Recommendations

To improve the methods used for this study I would recommend adjusting the time frame in which the data was gathered. In order to have enough time to gain entry into the community and reach out to more potential participants I would set aside eight months. This time frame would also allow stakeholders to participate in the study when they are in their off season, i.e. not during the summer tourism season or the fall moose hunting season.

Another recommendation would be to utilize additional methods of contacting participants in order to generate more interview data. Additional participants would have strengthened the validity of the study and allowed more data to compare perceptions between stakeholder groups more consistently. A larger participant pool would also help facilitate more equal representation of stakeholders from across the State of Maine.

A final recommendation would be to incorporate additional questionnaires into the study that were sent out to each stakeholder group. This would have generated additional data and provided more insight into the differences in perceptions between stakeholder groups. Stakeholder specific questionnaires would also have provided an opportunity to learn more about where people are getting information about the moose-winter tick dynamic and how this could be impacting their risk perceptions.

### Future research

More research is required to understand how winter ticks are impacting moose and if winter ticks are increasing past manageable levels. Disease ecology data has to be gathered about possible disease transmission between winter ticks and moose. It will be critical to understand how infestation limits moose health and it could impact the moose population in Maine. Concern about the influence of winter weather on both winter tick and moose survival warrants more research as well. If we understand how a warming climate could impact winter tick infestation on moose, we can better prepare wildlife managers to take action against winter ticks. Finally, additional research on risk perceptions and sources of information is required to understand what threats people believe winter ticks pose to Maine and how sources of knowledge about winter ticks could be shaping their risk perceptions.

## REFERENCES

- Addison, EM., RF McLaughlin, & JD Broadfoot. (1998) *Effects of winter tick (dermacentor albipictus) on blood characteristics of captive moose (alces alces)*. *Alces*,34(1):189-199.
- Addison, EM., RF McLaughlin, & JD Broadfoot. (1994). *Growth of moose calves (alces alces americana) infested and uninfested with winter ticks (dermacentor albipictus)*. *Can J Zool.*;72(8):1469-1476.\_doi: 10.1139/z94-194.
- Avruch, Kevin. (1998) *Culture and Conflict Resolution*. Washington DC: United States Institute of Peace Press.
- Baldrige, GD., GA Scoles, NY Burkhardt, B Schloeder, TJ Kurtti, & UG Munderloh. (2009). *Transovarial transmission of francisella-like endosymbionts and anaplasma phagocytophilum variants in dermacentor albipictus (acari: Ixodidae)*. *Journal of Medical Entomology*, 46(3), 625-632. doi:10.1603/033.046.0330
- Bath, Alistair J. (1998). *The role of human dimensions in wildlife resource research in wildlife management*. *Ursus*, 10, 349-355.
- Baxter, P., & S Jack. (2008). *Qualitative case study methodology: Study design and implementation for novice researchers*. *The Qualitative Report*, 13(4), 544.
- Braun, M., A Cross, & J Lukach. (2014). *State of big game species in Maine*. Colby College.
- Creswell, John. (2016). *30 Essential Skills for the Qualitative Researcher*. Sage Publications, Inc.
- Creswell, J., & C Poth. (2018). *Qualitative Inquiry & Research Design: Choosing Among Five Approaches*. Sage Publications, Inc.
- De Urioste-Stone, S., W McLaughlin, J Daigle, & J Fefer. (2018). *Applying Case Study Methodology to Tourism Research*. *Handbook of Research Methods for Tourism and Hospitality Management*. Edited by Robin Nunkoo: 407-427. Edward Elgar Publishing.
- Decker, DJ., DNT Evensen, WF Siemer, KM Leong, SJ Riley, MA Wild, & CL Higgins. (2010). *Understanding risk perceptions to enhance communication about human-wildlife interactions and the impacts of zoonotic disease*. *ILAR Journal*, 51(3), 255-261. doi:10.1093/ilar.51.3.255

- Decker, DJ., MA Wild, SJ Riley, WF Siemer, MM Miller, KM Leong, & JC Rhyan. (2006). Wildlife disease management: A manager's model. *Human Dimensions of Wildlife*, 11(3), 151-158. doi:10.1080/10871200600669908
- Drew, ML., & WM Samuel. *Factors affecting transmission of larval winter ticks, dermacentor albipictus (packard), to moose, alces L., in alberta, canada. Journal of Wildlife Diseases*. 1985;21(3):274-282. doi: 10.7589/0090-3558-21.3.274.
- Economic History of Maine*. (2015). Gale Encyclopedia of U.S. Economic History, edited by Thomas Riggs, 2nd ed., vol. 2, Gale, pp. 748-750.
- Ely, M., M Anzul, T Friedman, D Garner, & A McCormack Steinmetz. (1991). *Doing qualitative research: Circles within circles*. London, UK: The Falmer Press.
- Emmel, N. (2013). *Sampling and choosing cases in qualitative research: A realist approach*. Sage Publications, Inc.
- Fenstermacher, R. (1934) Further studies of diseases affecting moose. *Minnesota Bulletin*. (304).
- Fenstermacher, R., & WL Jellison. (1933). Diseases affecting moose. *Diseases affecting moose*.
- Filion, FL. (1980). *Human surveys in wildlife management*. Washington, D.C.: The Wildlife Society.
- Flick, U. (2009). *An introduction to qualitative research*. Lontoo: Sage Publications.
- Hanisch-Kirkbride, SL., SJ Riley, & ML Gore. (2013). *Wildlife disease and risk perception*. *Journal of Wildlife Diseases*, 49(4), 841-849. doi:10.7589/2013-02-031
- Huberman, M., & Miles. (2002). *The Qualitative Researcher's Companion*. Sage Publishers, Inc.
- Hunting in maine in 2013: A statewide and regional analysis of participation and economic contributions*. (2014). FL: Southwick associates.
- Jones, H. (2016). *Assessment of health, mortality, and population dynamics of moose in northern new hampshire during successive years of winter tick epizootics*. Dissertations & Theses Europe Full Text: Science & Technology.
- LaBonte, AM., HJ Kilpatrick, & JS Barclay. *Opinions about moose and moose management at the southern extent of moose range in connecticut*. *Alces*. 2013;49:83-98.

- Larter, NC. (2009). *A program to monitor moose populations in the dehcho region, northwest territories, canada*. *Alces*. 45:89-99.
- LeBlanc, JW., BE McLaren, C Pereira, M Bell, & S Atlookan. *First nations moose hunt in ontario: A community's perspectives and reflections*. *Alces*. 2011;47:163-174.
- Maine Office of Tourism Annual Report, 2016*. (2016). Economic and Community Development Documents. Retrieved from <[https://digitalmaine.com/decd\\_docs/168](https://digitalmaine.com/decd_docs/168)>
- Margaryan, L., & S Wall-Reinius. (2017). *Commercializing the unpredictable: Perspectives from wildlife watching tourism entrepreneurs in sweden*. *Human Dimensions of Wildlife*. 22(5):406-421. Accessed Jun 11, 2018. doi: 10.1080/10871209.2017.1334842.
- Malmsten, J., A Dalin, S Moutailler, E Devillers, M Gondard, & A Felton. (2018). *Vector-borne zoonotic pathogens in eurasian moose (alces alces)*. *Vector-Borne and Zoonotic Diseases*, 19(3), 27-211. doi:10.1089/vbz.2018.2277
- McLaughlin, RF., & EM Addison. (1986). *Tick (dermacentor albipictus)-induced winter hair-loss in captive moose (alces alces)*. *Journal of Wildlife Diseases*. 22(4):502-510. doi: 10.7589/0090-3558-22.4.502.
- McPherson, M., AW Shostak, WM Samuel. (2000). *Climbing simulated vegetation to heights of ungulate hosts by larvae of dermacentor albipictus (acari: Ixodidae)*. *J Med Entomol*. 37(1):114-120. doi: 10.1603/0022-2585-37.1.114.
- Miles, MB., AM Huberman, & J Saldana. (2014). *Qualitative data analysis: A methods sourcebook*. 3rd ed. Sage Publications, Inc.
- Miles, MB., & AM Huberman. (1994). *Qualitative data analysis: A methods sourcebook*. 2nd ed. Sage Publications, Inc.
- Mitchell, B. (1989). *Geography and resource analysis*. Harlow, Essex: Longman Group Limited, Longman Scientific & Technical.
- Moose. 2019a. Maine Department of Inland Fisheries and Wildlife. Retrieved from <<https://www.maine.gov/ifw/fish-wildlife/wildlife/species-information/mammals/moose.html>>.
- Moose. 2019b. Maine Department of Inland Fisheries and Wildlife. Retrieved from <<https://www.maine.gov/ifw/hunting-trapping/moose-permit.html>>

- Musante, AR., K Pedersen, & P Hall. (2014). *First reports of pseudorabies and winter ticks (dermacentor albipictus) associated with an emerging feral swine (sus scrofa) population in new hampshire*. Journal of Wildlife Diseases. 50(1):121-124.
- Needham, MD., & JJ Vaske. (2008). *Hunter perceptions of similarity and trust in wildlife agencies and personal risk associated with chronic wasting disease*. Society & Natural Resources, 21(3), 197-214. doi:10.1080/08941920701816336
- Neuzil, M., & E Freedman. (2018). *Restocking wolves on Isle Royale raises questions about which species get rescued*. The Conversation. Retrieved from <<http://theconversation.com/restocking-wolves-on-isle-royale-raises-questions-about-which-species-get-rescued-100808>>
- Oruganti, P., RB Garabed, & M Moritz. (2018). *Hunters' knowledge, attitudes, and practices towards wildlife diseases in ohio*. Human Dimensions of Wildlife. 0(0):1-12. doi: 10.1080/10871209.2018.1435839.
- Penobscot and the moose*. (2011). Penobscot Indian Nation. Pamphlet.
- Peterson, RL. (1955). *North american moose*. University of Toronto.
- Prins, H., & B McBride. (2007). *Asticou's Island Domain: Wabanaki Peoples At Mount Desert Island 1500-2000*. U.S. department of the interior ethnography program, Boston: National Park Service.
- Pybus, MJ. (1999). *Moose and ticks in alberta: A die off in 1998/99*. Alberta Environment.
- Recreational hunter and angler market report: Maine*. (2015). FL: Southwick associates.
- Samuel, B. (2004). *White as a Ghost: Winter Ticks & Moose*. Alberta: Federation of Alberta Naturalists.
- Samuel, WM. (2007). *Factors affecting epizootics of winter ticks and mortality of moose*. Alces. 43:39-48.
- Samuel, WM. (1991). *Grooming by moose (alces alces) infested with the winter tick, dermacentor albipictus (acari): A mechanism for premature loss of winter hair*. Can J Zool. 69(5):1255-1260. doi: 10.1139/z91-176.
- Samuel, WM., MS Mooring, & OI Aalangdong. (2000). *Adaptations of winter ticks (dermacentor albipictus) to invade moose and moose to evade ticks*. 36:183-195.

- Schwandt, Thomas. (2001). *Dictionary of Qualitative Inquiry*. 2nd ed. Sage Publications, Inc.
- Strauss, AL., & JM Corbin. (2015). *Basics of qualitative research : Techniques and procedures for developing grounded theory*. 4th ed. Sage Publications, Inc.
- Thomas, L., & A Cahn. (1932). *A new disease in moose*. *The Journal of Parasitology*. 18(4):219-231.
- Turner, DW. (2010). *Qualitative interview design: A practical guide for novice investigators*. *The Qualitative Report*, 15(3), 754.
- US Census Bureau. *Quickfacts: Maine*. Retrieved from <<https://www.census.gov/quickfacts/fact/table/me/PST045218>>
- Vaske, J. (2010). *Lessons learned from human dimensions of chronic wasting disease research*. *Human Dimensions of Wildlife*, 15(3), 165-179. doi:10.1080/10871201003775052
- Vaske, J., L Shelby, & M Needham. (2009). *Preparing for the next disease: The human-wildlife connection*. 244-261.
- Wabanaki Tribes. (2019). Retrieved from <<http://www.fourdirectionsmaine.org/wabanaki-tribes/>>
- Wattles, D., & S DeStefano. (2011). *Status and management of moose in the northeastern united states*. *Alces*, 47, 53.
- Welch, DA., & WM Samuel. (1989). *Evaluation of random sampling for estimating density of winter ticks (dermacentor albipictus) on moose (alces alces) hides*. *International Journal for Parasitology*. 19(6):691-693. doi: 10.1016/0020-7519(89)90050-7.
- Welch, DA., WM Samuel, & RJ Hudson. (1990). *Bioenergetic consequences of alopecia induced by dermacentor albipictus (acari: Ixodidae) on moose*. *J Med Entomol*. 27(4):656-660. doi: 10.1093/jmedent/27.4.656.
- Wilkinson, PR. (1967). *The distribution of dermacentor ticks in canada in relation to bioclimatic zones*. *Can J Zool*. 45(4):517-537. doi: 10.1139/z67-066.
- Winter Tick or Moose Tick. (n.d.) UMaine Cooperative Extension. Retrieved from <<https://extension.umaine.edu/ticks/maine-ticks/winter-tick-or-moose-tick/>>.
- World Population Review. (2019). Retrieved from <<http://worldpopulationreview.com/states/maine-population/>>

Yin, R. (2014). *Case Study Research: Design and Methods*. 5th ed. Sage Publications, Inc.

Zarnke, RL., WM Samuel, AW Franzmann, & R Barrett. (1990). *Factors influencing the potential establishment of the winter tick (dermacentor albipictus) in alaska*. Journal of Wildlife Diseases. 26(3):412-415. doi: 10.7589/0090-3558-26.3.412.



## APPENDICIES

# APPENDIX A: IRB APPROVAL

## APPLICATION COVER PAGE

- **KEEP THIS PAGE AS ONE PAGE – DO NOT CHANGE MARGINS/FONTS!!!!!!!!!!**
- **PLEASE SUBMIT THIS PAGE AS WORD DOCUMENT**

### APPLICATION FOR APPROVAL OF RESEARCH WITH HUMAN SUBJECTS Protection of Human Subjects Review Board, 400 Corbett Hall

**(Type inside gray areas)**

PRINCIPAL INVESTIGATOR: Asha DiMatteo-LePape      EMAIL: asha.dimatteolepape@maine.edu  
CO-INVESTIGATOR:      EMAIL:  
CO-INVESTIGATOR:      EMAIL:  
FACULTY SPONSOR: Sandra De Urioste-Stone (PhD)      EMAIL: sandra.de@maine.edu  
(Required if PI is a student):  
TITLE OF PROJECT: Perceptions of ticks and moose: Implications for outdoor recreation and cultural  
maintenance in Maine  
START DATE: June 11, 2018      PI DEPARTMENT: School of Forest Resources  
FUNDING AGENCY (if any):

STATUS OF PI: FACULTY/STAFF/GRADUATE/UNDERGRADUATE      Undergraduate

1. If PI is a student, is this research to be performed:  
 for an honors thesis/senior thesis/capstone?       for a master's thesis?  
 for a doctoral dissertation?       for a course project?  
 other (specify)
2. Does this application modify a previously approved project? N. If yes, please give assigned number (if known) of previously approved project:
3. Is an expedited review requested? Y.

Submitting the application indicates the principal investigator's agreement to abide by the responsibilities outlined in [Section I.E. of the Policies and Procedures for the Protection of Human Subjects](#).

Faculty Sponsors are responsible for oversight of research conducted by their students. The Faculty Sponsor ensures that he/she has read the application and that the conduct of such research will be in accordance with the University of Maine's Policies and Procedures for the Protection of Human Subjects of Research. REMINDER: if the principal investigator is an undergraduate student, the Faculty Sponsor MUST submit the application to the IRB.

Email this cover page and complete application to [UMRIC@maine.edu](mailto:UMRIC@maine.edu)

\*\*\*\*\*

**FOR IRB USE ONLY**      Application # 2018-05-12      Review (F/E): E      Expedited Category:

ACTION TAKEN:

- X  Judged Exempt; category      2      Modifications required? Yes Accepted (date)      6/11/2018  
 Approved as submitted. Date of next review: by      Degree of Risk:  
 Approved pending modifications. Date of next review: by      Degree of Risk:  
Modifications accepted (date):  
 Not approved (see attached statement)  
 Judged not research with human subjects

FINAL APPROVAL TO BEGIN

6/11/2018  
Date

01/2017

## APPENDIX B: INTERVIEW RECRUITMENT LETTER

<b>Interview Recruitment Script</b>
<p>Dear Mr.(s)...</p> <p>My name is Asha DiMatteo-LePape and I am an undergraduate student in the School of Forest Resources at the University of Maine. I am working under the supervision of Dr. Sandra De Urioste-Stone, a professor of nature-based tourism at the University of Maine. I am conducting a study to better understand risk perceptions of Winter Ticks (<i>Dermacentor albipictus</i>) in Maine and how these perceptions influence the attitudes and behaviors of multiple stakeholders. I will be looking at how perceived disease risk aligns with the actual transmission risk with moose as a reservoir.</p> <p><i>(Snowball sampling for key informant interview: You have been asked to participate in an interview because "xxx" participated in my study and thought you might be a suitable candidate for participation.)</i></p> <p>I would like to request an interview with you. The interview will take approximately one hour; if you agree, I will tape-record the interview.</p> <p>If you are willing to participate, please advise me about the date and time convenient for you to conduct the interview in person. Your help is very much appreciated.</p> <p>Respectfully yours,</p> <hr/> <p>Asha DiMatteo-LePape B.S. Student School of Forest Resources Nutting Hall University of Maine Orono, ME 04459-5755 Tel (802) 380 1245</p>

## APPENDIX C: INFORMED CONSENT

<b>Key Informant Interview Consent Form</b>
<p>You are requested to participate in a research project being conducted by Asha DiMatteo-LePape, an undergraduate student, and Dr. Sandra De Urioste-Stone, a faculty member, in the School of Forest Resources at the University of Maine. The goal of this project is to learn about the risk perceptions of Winter Ticks (<i>Dermacentor albipictus</i>) and how these perceptions influence attitudes and behaviors. You must be at least 18 years of age to participate.</p>
<b>What will you be asked to do?</b>
<p>I will schedule an interview with you and request your participation. The interview will take approximately one hour. With your permission, I will tape-record the interview.</p> <p>In any publication or presentations, your names will not be revealed, unless you specifically ask us to use your name.</p>
<p><u>Example of potential interview questions:</u></p> <ul style="list-style-type: none"><li>• What kinds of ticks do you know about or have had interactions with in Maine?</li><li>• How do you think Winter Ticks impact human health? Wildlife health?</li><li>• What impacts do you believe Winter Ticks have on moose and moose populations in Maine?</li></ul>
<b>Voluntary</b>
<p>At any time throughout the interview, you can stop and refrain from answering questions you do not want to address.</p>
<b>Risks</b>
<p>Except for your time and inconvenience, there are no risks to you from participating in this study.</p>
<b>Benefits</b>
<p>While this study may have no direct benefit to you, this research may help in creating a better understanding of the risk perceptions of Winter Ticks and any related changes in attitudes and behaviors.</p>
<b>Confidentiality</b>
<p>Data will be kept in the investigator's locked office. Your name or other identifying information will not be reported in any publications. A code number will be used to protect your identity. The key linking your name to the data will be destroyed after data analysis is complete. Audio recordings will be kept in a password protected computer,</p>

only to be accessed by investigators and will be destroyed after data analysis is complete. Transcribed data will be kept in a password protected computer, only to be accessed by investigators until data analysis is complete.

**Contact information**

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

Asha DiMatteo-LePape at (802) 380 1245; [asha.dimatteolepape@maine.edu](mailto:asha.dimatteolepape@maine.edu); or [128 Nutting Hall, University of Maine, Orono, ME 044669-5755](#).

Dr. Sandra De Urioste-Stone at (207) 581 2885; [sandra.de@maine.edu](mailto:sandra.de@maine.edu); or [237 Nutting Hall, University of Maine, Orono, ME 04469-5755](#).

If you have any questions about your rights as a research participant, please contact the Office of Research Compliance, University of Maine, 207/581-1498 or 207/581-2657

(or e-mail ([umric@maine.edu](mailto:umric@maine.edu)))

APPENDIX D: INTERVIEW PROTOCOLS

Appendix D-1

Hunters

<b>Protocol 1_Hunters</b>
<b>Time:</b>
<b>Date:</b>
<b>Place:</b>
<b>Interviewer:</b>
<b>Interviewee:</b>
<b>Interviewee purpose/characteristics:</b>
<b>Check:</b>
<b>Introduction:</b>
<b>Position Held:</b>
<b>Questions</b>
<b>Individual</b>
<ol style="list-style-type: none"><li>1. How long have you been hunting?</li><li>2. What does hunting mean to you?</li><li>3. How would you describe your relationship or interactions with the outdoors?</li></ol>
<b>Human health</b>
<ol style="list-style-type: none"><li>4. What do you think about when you hear the word "tick"?</li><li>5. What kinds of ticks do you know about or have had interactions with in Maine?</li><li>6. What risks do you believe ticks pose to humans?</li></ol>

- 7. What do you know about Winter Ticks?**
- 8. What kinds of interactions have you had with Winter Ticks, if any?**
- 9. What demographic do you believe comes into contact with Winter Ticks the most?**
- 10. How do you think Winter Ticks impact human health? Wildlife health?**

#### **Moose health**

- 11. How would you describe the moose population in Maine right now?**
- 12. Have you seen any differences between moose populations now and moose populations ten years ago?**
- 13. What do you believe moose populations in Maine will look like ten years in the future?**
- 14. What impacts do you believe Winter Ticks have on moose and moose populations in Maine?**

#### **Zoonotic disease**

- 15. Do you think that Winter Ticks could act as vectors for disease transmission?**
- 16. How often do you have conversations with people about ticks in general?**
- 17. Have you had conversations about Winter Ticks specifically? What was the context?**

#### **Recreation opportunities**

- 18. If at all, how do you think that Winter Ticks influence hunters?**
- 19. How do you think the stigma of the word "tick" influences decision making among hunters?**
- 20. Do you think that Winter Ticks have influenced the types of hunting or outdoor activities people are engaging in? How?**
- 21. How do you see the level awareness of Winter Ticks among hunters?**
- 22. Have you as a hunter ever altered your behavior to accommodate for ticks?**

**23. If at all, how do you think moose health influences recreation in Maine?**

**24. What kinds of impact do you potentially see winter ticks having on hunting practices, now or in the future?**

**25. How do you see Winter Ticks influencing future recreation opportunities in Maine?**

**Cultural identity**

**26. What cultural practices do you believe Winter Ticks have influenced in Maine, if any?**

**27. What impacts could Winter Ticks have on Maine culture?**

**Economic vitality**

**28. If Winter Ticks are affecting hunter behaviors, how, if at all, could this impact outfitter and hunter revenues and the economy?**



Appendix D-2

Outfitters/Wildlife Managers

<b>Protocol 2_ Outfitters/Wildlife Managers</b>
<b>Time:</b>
<b>Date:</b>
<b>Place:</b>
<b>Interviewer:</b>
<b>Interviewee:</b>
<b>Interviewee purpose/characteristics:</b>
<b>Check:</b>
<b>Introduction:</b>
<b>Position Held:</b>
<b>Questions</b>
<b>Individual</b>
<ol style="list-style-type: none"><li>1. How long have you been working in your field?</li><li>2. What got you interested in working in this field?</li><li>3. How would you describe your role as an outfitter?</li><li>4. How would you describe your relationship or interactions with the outdoors?</li></ol>
<b>Human health</b>
<ol style="list-style-type: none"><li>5. What do you think about when you hear the word "tick"?</li><li>6. What kinds of ticks do you know about or have had interactions with in Maine?</li><li>7. What risks do you believe ticks pose to humans?</li><li>8. What do you know about Winter Ticks?</li></ol>

9. What kinds of interactions have you had with Winter Ticks, if any?
10. What demographic do you believe comes into contact with Winter Ticks the most?
11. How do you think Winter Ticks impact human health? Wildlife health?

#### **Moose Health**

12. How would you describe the moose population in Maine right now?
13. Have you seen any differences between moose populations now and moose populations ten years ago?
14. What do you believe moose populations in Maine will look like ten years in the future?
15. What impacts do you believe Winter Ticks have on moose and moose populations in Maine?

#### **Zoonotic disease**

16. How often do you have conversations with people about ticks in general?
17. Have you had conversations about Winter Ticks specifically? What was the context?
18. Do you think that Winter Ticks could act as vectors for disease transmission?

#### **Recreation opportunities**

19. Do you think that Winter Ticks have influenced the types of outdoor activities people are engaging in? How?
20. If at all, how do you think that Winter Ticks influence outdoor recreationists?
21. How do you think the stigma of the word "tick" influences recreationist decision making?
22. How do you see the level awareness of ticks in general and Winter Ticks among outdoor outfitters?
23. Have you as an outfitter ever altered your business models to accommodate for ticks?

**24. If at all, how do you think moose health influences recreation in Maine?**

**25. How do you see Winter Ticks influencing future hunting and recreation opportunities in Maine?**

**Cultural identity**

**26. What cultural practices do you believe Winter Ticks have influenced in Maine, if any?**

**27. What kinds of impact do you potentially see winter ticks having on cultural practices, now or in the future?**

**Economic vitality**

**28. If Winter Ticks are affecting recreationist behaviors, how, if at all, could this impact outfitter revenues and the economy?**

Appendix D-3

Wabanaki Citizens

<b>Protocol 3_ Wabanaki citizens</b>
<b>Time:</b>
<b>Date:</b>
<b>Place:</b>
<b>Interviewer:</b>
<b>Interviewee:</b>
<b>Interviewee purpose/characteristics:</b>
<b>Check:</b>
<b>Introduction:</b>
<b>Position Held:</b>
<b>Questions</b>
<b>Individual</b>
<ol style="list-style-type: none"><li><b>1. How would you describe your relationship or interactions with the outdoors?</b></li><li><b>2. How frequently do you spend time in the outdoors?</b></li></ol>
<b>Human health</b>
<ol style="list-style-type: none"><li><b>3. What do you think about when you hear the word "tick"?</b></li><li><b>4. What kinds of ticks do you know about or have had interactions with in Maine?</b></li><li><b>5. What risks do you believe ticks pose to humans?</b></li><li><b>6. What do you know about Winter Ticks?</b></li><li><b>7. What kinds of interactions have you had with Winter Ticks, if any?</b></li><li><b>8. How do you think Winter Ticks impact human health? Wildlife health?</b></li></ol>

### **Moose health**

- 9. How would you describe the moose population in Maine right now?**
- 10. Have you seen any differences between moose populations now and moose populations ten years ago?**
- 11. What do you believe moose populations in Maine will look like ten years in the future?**
- 12. What demographic do you believe comes into contact with Winter Ticks the most?**
- 13. If at all, how do you think that Winter Ticks influence indigenous people?**
- 14. How do you think the stigma of the word "tick" influences decision making among indigenous people?**

### **Zoonotic disease**

- 15. Do you think that Winter Ticks could act as vectors for disease transmission?**

### **Recreation opportunities**

- 16. Do you think that Winter Ticks have influenced the types of hunting or outdoor activities that indigenous people are engaging in? How?**
- 17. How do you see the level awareness of Winter Ticks among indigenous people?**
- 18. How often do you have conversations with people about ticks in general?**
- 19. Have you had conversations about Winter Ticks specifically? What was the context?**
- 20. Have you ever altered your behavior to accommodate for ticks?**
- 21. If at all, how do you think moose health influences recreation in Maine?**
- 22. How do you see Winter Ticks influencing future hunting and recreation opportunities in Maine?**

### **Cultural identity**

- 23. If any, what kinds of folklore or stories does your culture have about**

moose?

**24. What is the significance of moose to your culture?**

**25. If any, what kinds of folklore or stories does your culture have about ticks?**

**26. What cultural practices do you believe Winter Ticks have influenced, if any?**

**27. What kinds of impact do you potentially see winter ticks having on cultural practices, now or in the future?**

**28. What impacts could ticks in general have on native cultures in Maine?**

**29. What impacts do you believe Winter Ticks have on moose and moose populations in Maine?**

**30. How could a decrease in Moose populations affect indigenous cultures and practices in Maine?**

**Economic vitality**

**31. If Winter Ticks are affecting recreationist behaviors, how, if at all, could this impact the economy?**

APPENDIX E: LITEATURE KEYWORDS AND DATABASES INCLUDING

NUMBER OF RELEVANT PUBLICATIONS IDENTIFIED

Keywords			Databases with Number of Publications Returned				
Keyword 1	Keyword 2	Keyword 3	Ebscohost	Jstor	Ingenta	Cabi	Web of science
perception*	"native american*"	moose	1	0	0	0	0
meaning*	"native american*"	moose	7	0	0	0	0
symbol*	"native american*"	moose	5	0	0	0	0
symbol*	"native american*"	tick*	5	0	0	0	0
meaning*	"native american*"	tick*	3	0	0	0	0
perception*	"native american*"	tick*	0	0	0	0	0
perception*	indigenous*	moose	3	0	0	1	1
meaning*	indigenous*	moose	4	1	0	0	0
symbol*	indigenous*	moose	2	0	0	0	0
symbol*	indigenous*	tick*	7	0	0	1	1
meaning*	indigenous*	tick*	8	1	2	2	1
perception*	indigenous*	tick*	4	0	0	5	3
perception*	aboriginal*	moose	5	0	0	1	2
meaning*	aboriginal*	moose	6	0	0	0	0
symbol*	aboriginal*	moose	4	0	0	0	0
symbol*	aboriginal*	tick*	0	0	0	0	1
meaning*	aboriginal*	tick*	1	0	0	0	0
perception*	aboriginal*	tick*	0	0	0	0	1
perception*	"first nation*"	moose	1	0	1	0	0
meaning*	"first nation*"	moose	6	0	0	0	1
symbol*	"first nation*"	moose	4	0	0	0	0
symbol*	"first nation*"	tick*	2	0	0	0	0
meaning*	"first nation*"	tick*	2	0	1	0	0
perception*	"first nation*"	tick*	3	0	1	1	2
perception*	hunter*	moose	4	0	1	5	5
meaning*	hunter*	moose	6	0	2	1	0
symbol*	hunter*	moose	6	0	0	0	0

symbol*	hunter*	tick*	7	0	0	0	0
meaning*	hunter*	tick*	2	0	0	0	0
perception*	hunter*	tick*	0	0	0	1	0
perception*	outfitter*	moose	0	0	0	0	0
meaning*	outfitter*	moose	0	0	0	0	0
symbol*	outfitter*	moose	0	0	0	0	0
symbol*	outfitter*	tick*	1	0	0	0	0
meaning*	outfitter*	tick*	0	0	0	0	0
perception*	outfitter*	tick*	0	0	0	0	0
hunter*	tick*	/	366	3	2	1217	132
hunter*	"winter tick*"	/	9	1	0	2	4
hunter*	moose	/	964	23	20	339	230
hunter*	"chronic waste disease*"	/	2	0	26	83	0
outfitter*	tick*	/	31	0	0	0	0
outfitter*	"winter tick*"	/	0	0	0	0	0
outfitter*	moose	/	31	0	0	1	0
outfitter*	"chronic waste disease*"	/	0	0	1	1	0
"native american*"	tick*	/	154	6	0	4	3
"native american*"	"winter tick*"	/	0	4	0	0	0
"native american*"	moose	/	91	17	3	1	6
"native american*"	"chronic waste disease*"	/	0	4	0	0	0
indigenous	tick*	/	620	3	32	1196	228
indigenous	"winter tick*"	/	1	2	2	6	1
indigenous	moose	/	166	8	5	59	42
indigenous	"chronic waste disease*"	/	0	2	1	8	0
aboriginal*	tick*	/	87	2	0	11	13
aboriginal*	"winter tick*"	/	0	0	0	0	0
aboriginal*	moose	/	150	7	3	9	22
aboriginal*	"chronic waste disease*"	/	0	0	1	2	0
"first nation*"	tick*	/	152	0	24	16	8
"first nation*"	"winter tick*"	/	0	0	0	0	0
"first nation*"	moose	/	161	0	4	17	14
"first nation*"	"chronic waste disease*"	/	0	0	1	1	0



symbol*	moose	Maine	6	0	0	0	0
meaning*	moose	Maine	3	0	9	0	0
perception*	moose	Maine	1	0	0	1	1
symbol*	tick*	Maine	3	0	2	0	0
meaning*	tick*	Maine	1	0	27	0	0
perception*	tick*	Maine	1	0	5	0	1
perception*	hunter*	Maine	0	0	4	1	0
indigenous	moose	Maine	3	0	0	1	0
"native american*"	moose	Maine	8	0	0	0	0
"first nation*"	moose	Maine	2	0	0	0	0
tourism	moose	Maine	32	0	0	1	0
tourism	tick*	Maine	4	0	1	0	1
moose	health	Maine	30	0	0	5	2
moose	disease	Maine	22	0	2	12	2
moose	economy	Maine	11	0	1	1	0
zoonotic	disease	Maine	74	0	209	38	1
zoonotic	moose	Maine	4	0	0	1	0
zoonotic	perception*	Maine	0	0	2	0	0
recreation	moose	maine	65	0	0	0	0
recreation	tick*	maine	0	0	0	0	1
recreation	moose	/	61	3	3	28	23
recreation	tick*	/	312	1	7	156	58
culture	moose	maine	0	0	0	1	0
"risk perception*"	"winter tick*"	/	0	0	0	0	0
"risk perception*"	moose	/	4	0	3	3	4
"risk perception*"	behavior	hunting	71	0	2	5	5
"risk perception*"	behavior	tourism	94	1	8	73	50
<b>Total relevant per database:</b>			<b>25</b>	<b>0</b>	<b>15</b>	<b>14</b>	<b>1</b>

APPENDIX F: SUMMARY OF LITERATURE RELATED TO THE STUDY

<b>Author and (year)</b>	<b>Context (country / state)</b>	<b>Research objectives, questions, hypotheses</b>	<b>Methodology and methods</b>	<b>Theoretical framework (theory)</b>	<b>Major findings and suggestions</b>	<b>Citation</b>
Addison, McLaughlin, Broadfoot (1998)	Ontario	Analyze effect of ticks on hematologic and biochemical parameters in moose	Manual infestation of moose with winter ticks, blood testing	Winter ticks effect blood characteristics of moose	Limited impact of ticks on hematologic and biochemical parameters of well-fed moose. Significant variation in blood parameters	(Addison, McLaughlin, & Broadfoot, 1998)
Addison, McLaughlin, Broadfoot (1994)	Ontario	Effect of winter tick infestation on moose calf growth	/	Winter ticks may limit moose calf growth	“infestation may have caused a reduction in the mass gain of moose in autumn” “heavy autumn tick infestation may predispose calves to reduced physical fitness and likelihood of survival during winter”	(Addison, McLaughlin, & Broadfoot, (1994)

Drew, Samuel (1985)	Alberta, Canada	To determine the factors that affect transmission of larval winter ticks to moose	Field studies, larvae flagging	Larval activity of winter ticks contributes to moose infestation	Larvae ascended vegetation in autumn... larvae clumped on the tips of vegetation... did not exhibit a diurnal, vertical migration... activity was temperature dependent... no obvious preference of vegetation species” “transmission of larvae to moose was probably facilitated by synchrony of the larval activity period with the moose breeding season”	(Drew & Samuel, 1985)
Fenstermacher (1934)	Minnesota, USA	Review of diseases affecting moose (reports/studies) and reports of symptoms and possible causation	Review of disease reports/studies, moose examinations, necropsy, blood testing, animal inoculation, tick attachment experiments	Symptomatology, serology, bacteriology, histopathology	Moose are not affected by a seasonal disease, heavy infestations of <i>D. albipictus</i> are not necessarily found on diseased moose, many animal parasites collected from moose. Ticks as vectors of bacterial or protozoan disease possible but failed in	(Fenstermacher, 1934)

					inoculation studies. Moose death not a result of one pathogen, many factors reduce moose vitality.	
Fenstermacher, Jellison (1933)	Minnesota, USA	Review of diseases affecting moose (reports/studies) and reports of symptoms and possible causation	Review of prior research, literature review, necropsy, blood testing, bacteriological testing, animal inoculation	Disease causation, transmission, symptomatology, serology, bacteriology	No findings have identified the cause of moose sickness and death. No bacteriological findings, possible pathogenic organism isolated from blood, only constant parasite is <i>Dermacentor albipictus</i> . Moose as a vector of disease is possible but transmission of infection to guinea pigs and rabbits failed. Emancipation symptoms could be due to tick presence and limited food.	(Fenstermacher & Jellison, 1933)

LaBonte, Kilpatrick, Barclay (2013)	Connecticut, USA	To “assess landowner and hunter perceptions about status, management, and concerns associated with small moose population in Connecticut”	Landowners mail surveys: Likert-scale, hunter survey (anyone purchasing a firearm hunting license or combination hunting/fishing license)	Human acceptability of presence and consequence of a wildlife species will eventually define the wildlife acceptance capacity (WAC)	Landowners beliefs: wildlife and management is important. Knowledge of moose: majority correctly estimated that there were <100 moose in Connecticut. Expected reduction in WAC if moose-human conflicts increase measurably.	(LaBonte, Kilpatrick, & Barclay, 2013)
Larter (2009)	Northwest territory, Canada	Determine “baseline information on moose populations and to foster community-based monitoring of Moose”	Aerial survey, harvest sampling	Change of moose populations through the collaboration of TEK and governmental technical support	“population density and calf: cow ratios were reasonable... low incidence of diseases and parasites, low levels of cadmium in organ tissue, and that moose were mostly in good or excellent body condition based on observation and fat indices” “successfully combining the knowledge and cooperation of First Nation moose harvesters with the technical	(Larter, 2009)

					support of government biologists to secure valuable biological information for baseline data to monitor change	
LeBlanc, McLaren, Pereira, Bell, Atlookan (2011)	Ontario, Canada	Explore community perspectives of current and historical management of moose hunting between First Nations and provincial managers	First Nations moose hunter questionnaire, Chief and Council consultation s/ surveys	Natural resource management is difficult when there are strained relationships from misunderstandings of jurisdictional authority	Restricted dialogue between First Nations and provincial managers leads to unaccounted for uses and underestimated moose harvests. Estimations of moose populations and harvest allocations have to be determined through consultation.	(LeBlanc, McLaren, Pereira, Bell, & Atlookan, 2011)

Margaritan, Wall-Reinius (2017)	Sweden	“Understanding commercialization of uncontrollable natural phenomena (wild animals) in a similarly uncertain natural setting (wilderness)”	Interviews, participant observation	“specific challenges associated with these businesses: lack of control as an inherent property of wildlife watching tourism, agency and continuous negotiation of uncertainties within the operational setting, importance of guide performances and “secondary” experiences, and using uncertainty as a way of enhancing authenticity”	Uncertainty mitigation strategy’s; “unpredictability becomes synonymous with a high degree of authenticity”; “authenticity in the wildlife watching experiences can contribute to minimizing negative impacts of tourism on wildlife”	(Margaritan & Wall-Reinius, 2017)
---------------------------------	--------	--	-------------------------------------	---	---	-----------------------------------

McLaughlin, Addison (1986)	Ontario, Canada	Moose observed for changes in hair-loss, body condition and number, stages, and distribution of ticks after infestation by winter ticks	Manual infestation of winter ticks on moose, observation of moose and tick conditions	Winter ticks lead to abnormal hair loss in infested moose	“winter hair-loss was observed only in moose infested with ticks and was correlated positively with the total number of adult ticks” “moose with extensive premature hair-loss had less pericardial and abdominal visceral fat than moose with little or no hair-loss”	(McLaughlin & Addison, 1986)
McPherson, Shostak, Samuel (2000)	Alberta, Canada	Vegetation height determines the height of questing winter tick larvae	Simulation of vegetation to ungulate transmission using nylon rods as simulated vegetation	Winter tick larvae ascend vegetation and form clumps in order to attach to passing ungulate hosts	“most larvae stopped climbing and formed clumps 50-190cm above ground, which coincided with torso heights of moose...clump number, size, and height did not correlate with weather conditions...larvae appear to determine their height above ground in the absence of external cues, but this mechanism may be modified by external	(McPherson, Shostak, & Samuel, 2000)



					conditions”	
Musante, Pedersen, Hall (2014)	New Hampshire, USA	Feral swine populations could carry pseudorabies virus (PRV) and winter ticks	Feral swine blood samples tested for classic swine fever (CSF), pseudorabies (PR), swine brucellosis (SB), and various other diseases	“expansion of feral swine (Sus scrofa) populations into new geographic regions is of concern not only due to increased range but also because they carry diseases and parasites that pose a threat to humans, livestock, and wildlife into new areas”	Feral swine could increase host diversity for parasites such as the winter tick, a species that can regionally impact moose (Alces alces) survival	(Musante, Pedersen, & Hall, 2014)
Oruganti, Garabed, Moritz (2018)	Ohio, USA	“how Ohio hunters’ knowledge, attitudes, and practices affect risk exposure to infectious disease”	Ethnographic methods, semi-structured interviews, online survey, KAP model	Risk perception, KAP framework	“They perceived low-to-no risk of exposure to infectious diseases. Although hunters were generally knowledgeable about infectious wildlife diseases, they were more concerned about the impact on wildlife populations than	(Oruganti, Garabed, & Moritz, 2018)

					their own health.”	
Peterson (1955)	North America (USA, Canada)	To chronic reports of moose disease and symptoms	Literature review, analysis of reports	Disease transmission	Diseased moose exhibit many symptoms and can suffer from many different maladies. No conclusive findings have been made about moose disease. <i>D. albipictus</i> decreased moose mortality making them more vulnerable to disease.	(Peterson, 1955)
Pybus (1999)	Alberta, Canada	Factors effecting significant mortality of moose in 1999 in Alberta	Occurrence reports, deceased moose inspection	Interactions among moose, ticks, habitat, and weather influence excessive mortality of moose, especially calves	“excessive mortality of moose, particularly calves, occurred in late winter. The outbreak is considered a direct result of the interactions among moose, ticks, habitat, and weather. Weather appears to have been the ultimate force driving the interactions”	(Pybus, 1999)

Samuel (2007)	Alberta, Canada	Factors of moose mortality influenced by winter tick infestation	Observations from the air of hair damage and loss on moose	Changes in hair damage and loss coincide with changes in numbers of ticks on moose	“extrinsic influences (weather, vegetative structure, host factors) play a role, possibly independent of moose density” “warmer and shorter winters result in increased survival of adult female ticks...and increased tick populations on moose the following year”	(Samuel, 2007)
Samuel (1991)	Canada	Determine mechanism for premature winter hair loss in moose	Experimental infestation of moose with winter ticks, observation	Grooming by infested moose is a mechanism for premature winter hair loss	“Grooming by infested moose was more frequent and of longer duration than grooming by un-infested moose...resulted in premature loss of winter hair”	(Samuel, 1991)

Samuel, Mooring, & Aalangdong (2000)	Newfoundland	Explore the adaptations of winter ticks to invade moose and the adaptations of moose to evade ticks	/	Winter ticks have adapted to invade moose and moose have adapted to evade winter ticks	“larval winter ticks display such behavior as aggregating in clumps on the leeward side of vegetation at heights of preferred ungulate hosts.” “Moose... avoid or reduce infestation by ticks by evading tick larvae on vegetation, tolerating tick-foraging magpies, and grooming to remove ticks”	(Samuel, Mooring, & Aalangdong, 2000)
Thomas, Cahn (1932)	USA, Canada	Investigate the disease that causes moose death in winter and spring: cause of organism producing disease and role of <i>Dermacentor albipictus</i> in transmission	Experimental infestation of guinea pigs, rabbits, bull calf, and lamb by <i>D. albipictus</i> from diseased moose	Disease transmission, inoculation	Symptoms of inoculated guinea pigs similar to those of diseased moose. Isolated organism from engorged ticks causes infection in test animals. (STUDY NOT UPHOLD BY FURTHER EXPERIMENT)	(Thomas & Cahn, 1932)

Vaske, Needham, Shelby (2009)	USA	Provide an approach to studying the human dimensions of wildlife disease	Literature review	Systematic program of human dimension inquiry	Systematic inquiry: behavioral intentions, concerns and perceptions of risk, information sources and knowledge, trust in wildlife agencies, acceptance of management, other stakeholders, economic impacts,	(J. Vaske, Shelby, & Needham, 2009)
Welch, Samuel (1989)	Alberta, Canada	Evaluation of random sampling for estimating density of winter ticks on moose hides	Winter tick densities were determined by dissolving hide quadrants in potassium hydroxide solution and counting ticks	Total tick density can be determined from quadrants	“random sampling of 15% of the quadrants produces a good estimate of tick density”	(Welch, Samuel, 1989)

Welch, Samuel, Hudson (1990)	Canada	Effects of winter ticks on bioenergetics of moose	Fasting metabolic rates, respiration rates, respiratory minute volumes, and fasted weights were measured on infested moose and controls	Winter ticks cause alopecia, winter ticks can influence moose health	“destruction of winter hair accompanied a reduction in respiratory minute volumes and respiration rates of heat-stressed moose” “Infestations produced no detectable effects on fasting metabolic rates or weight changes”	(Welch, Samuel, Hudson, 1990)
Wilkinson (1967)	Alberta, Canada	To determine the distribution of Dermacentor ticks in relation to bioclimatic zones	Dermacentor tick collection	Dermacentor tick distribution is impacted by temperature, aspect, slope, vegetation	“D. albipictus occurs from the east to the west coast. Because of the winter activity of its larvae, allowing the whole summer for egg development, it is able to penetrate much farther north than the other two species”	(Wilkinson, 1967)
Zarnke, Samuel, Franzmann, Barrett, 1990	Alaska, USA	To determine the factors influencing potential winter tick establishment	Experimental introduction of winter ticks and observation of hatching and survival rates	Environmental factors would influence survival of winter ticks if translocated to Alaska	“Perhaps the absence of D. albipictus in Alaska is a result of lack of movement of infested moose from the south. Other possible factors include	(Zarnke, Samuel, Franzmann, Barrett, 1990)

					(1) genetic differences of moose from Alaska and moose from more southerly areas, (2) densities of moose, and (3) habitat-tick relationships” “Another factor in tick survival is the length of winter”	
--	--	--	--	--	--	--

## AUTHOR'S BIOGRAPHY

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.

At the University of Maine, Asha double majored 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 at UMaine working for the Maine Bound Outdoor Adventure Center introducing students to the beautiful Maine landscape through outdoor adventure. She also worked as an undergraduate research assistant where she transcribed oral interviews, conducted visitor surveys, and immersed herself in the world of qualitative research.

She has accepted an offer to pursue Forest Resource Management at the University of Maine for the fall 2019. She is excited to learn more about resource management and conservation science while also working as a Graduate Assistant for the Outdoor Leadership program in the university's Kinesiology and Physical Education department.