Examining Local Experiential Knowledge Holders' Spatial and Relational Values of Wildlife in the Chignecto Isthmus Linkage Area, Canada

by

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Dalhousie University is located in Mi'kma'ki,
the ancestral and unceded territory of the Mi'kmaq.
We are all Treaty people.

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ABSTRACT

The Chignecto Isthmus is the sole terrestrial connection between the Canadian province of Nova Scotia and mainland North America, measuring approximately 17 kms in width at its narrowest. It facilitates movement of an array of wildlife yet is threatened by human infrastructure and other impacts on the landscape, including sea-level rise and flooding due to climate change. Local people's knowledge and relational values surrounding wildlife are not well understood, but may represent an untapped resource, diversifying and complementing scientific data and models. Accordingly, 34 participants with local tacit knowledge were engaged in semi-structured, map-based, in-person interviews about wildlife presence and movement patterns. A subset of 12 participants was engaged in two subsequent workshops to refine local-consensus maps of wildlife presence and movement pathways, as derived from the interview data. Their relational values toward wildlife were also analyzed by applying Stephen Kellert's 1996 values framework to the interview data.

Mapped findings show detailed local knowledge of spatial patterns of wildlife presence and movement patterns. Many mapped results coincide with a high-probability wildlife movement pathway generated in a previous computer-based modeling study, and others extend beyond the study area used in the model. Other local-knowledge-generated findings elaborate why wildlife may be moving in a specific way across the region and why some populations may be declining, adding nuance to the spatial data and enriching existing scientific data. The textual analysis of relational values found that local knowledge holders value direct observances and engagement with local wildlife and habitat, and that these valued relationships are enriched through an appreciation of their ecological roles. They are further grounded in an awareness of threats to wildlife and their population fluctuations due to human activities. Although they value wildlife in utilitarian ways, they also express a moral imperative for sustainable use, rather than over-exploitation, of wildlife and their habitats.

The information that was gathered through mixed methodologies of interviews, workshops, and integrated participatory mapping supplements and enhances the scientific data and models of wildlife movement patterns in the region. Such qualitative approaches provide greater understanding of how local knowledge holders value wildlife and how wildlife moves and is affected by landscape change, helping to bridge the communication gaps between local knowledge holders and conservation and land use planners in the region.

LIST OF ABBREVIATIONS USED

GIS	Geographic information system
NS	Nova Scotia
NB	New Brunswick
NCC	The Nature Conservancy of Canada
OHV	Off highway vehicle
PPGIS	Public participation geographic information system
SES	Social-ecological system

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CHAPTER 1 - Introduction

1.1 Rationale for the thesis in conservation theory and in place

There is a global recognition in conservation theory of the need for social science research and integration of social science methods in conservation initiatives (Bennett et al., 2017; Teel et al., 2010). Initiatives aimed at conserving biodiversity require that both ecological and social factors be considered to achieve "social acceptability of conservation actions" (Brown et al., 2018, p. 452). Interest and involvement in the human dimensions of wildlife research and management has been growing (Teel & Manfredo, 2010), with the increased recognition that the "preservation of biodiversity depends upon public commitment to its protection" (Jacobson & Duff, 1998, p.263). Biodiversity conservation is a human endeavor, "driven by people's values toward the management of land and resources" (Jacobson & Duff, 1998, p.263). Because of this human component, "the natural science methods of conservation biology are insufficient to find solutions to complex conservation problems that have social dimensions" (Bennett et al., 2017, p.57).

To consider human behaviour in fostering positive change in the realm of conservation, we first need to understand the underlying emotions, values, motivations, and other influencing factors for such behaviour. Social science methodologies are necessary for teasing out the nuances of human thought, motivation, and behaviour invisible to natural scientific methods (Bennett et al., 2017). Further, by involving local people in the research process, it is likely there will be more buy-in and support for any initiatives incorporating the publicly generated data (Nyhus, 2016; Sieber, 2006). Conservation initiatives that ignore the human dimensions often are met with backlash from local communities due to the "exclusionary planning and implementation processes" (Bennett & Roth, 2018, p.A6).

Through my research, I aim to contribute to the mainstreaming of social science in conservation research by exploring local tacit knowledge and relational values of wildlife in the Chignecto Isthmus region of Nova Scotia (NS) and New Brunswick (NB), Canada. The incorporation of social science into the conservation research within this region will contribute to growing the field of place-based studies in ways that are meaningful to humans and communities, especially in areas, such as the Chignecto isthmus, where humans and wildlife have daily meaningful interactions (Bennett et al., 2017; Bennett & Roth, 2018; Jacobson & Duff, 1998; Manfredo et al., 2011; Teel & Manfredo, 2010).

In terms of place, the Chignecto Isthmus represents an ideal study area for exploring social science in a conservation context. While generally rural, it is heavily used by people. For example, it serves as a major transportation, energy and communication corridor, contains small towns and settlements, and provides outdoor recreational opportunities. As such, humans and wildlife interact daily and are interdependent on one another. It has a rich and varied historical culture as a traditional territory of the Mi'kmaq, the First Nation peoples who have lived there since time immemorial (i.e., at least 12,000 years). It was an important area to Acadian settlers, who built dykes and transformed the rich salt marshes for farming until expelled by the British, and then resettled by New England Planters and later European settlers (Wynn, 1979). It now serves as an important trade corridor while simultaneously serving as a key terrestrial linkage for biodiversity (Macdonald, & Clowater, 2005; Noseworthy, 2014; Nussey, 2016; Nussey & Noseworthy, 2018; Reining et al., 2006). The region is at risk of impacts from flooding and sea-level rise associated with accelerated climate change impacts and land subsidence (David A Greenberg et al., 2012a). Accordingly, it is important to consider socio-ecological aspects during planning and decision making for both conservation of wildlife and mitigation of impacts to human infrastructure as climate change continues to pose significant risks. Thus, it is essential that local citizens' perspectives and experiences be considered in sustainable land use planning to benefit both humans and wildlife.

Many studies in the region have focused on natural science and engineering considerations (e.g. Mackinnon & Kennedy, 2008; Nussey & Noseworthy, 2018; Barnes, 2019). Yet, a paucity of social science studies remains, despite the clear relevance of such methods and data to the issue of wildlife conservation. Importantly, recent survey research has examined whether incentive programs in Nova Scotia aimed at encouraging landowners to protect habitat for the endangered wood turtle are leading to a focus on extrinsic motivations (e.g. payment for participating), described as motivation crowding, in farmers. Research by Goodale et al. (2015) included a wider suite of species, using elicitation-based surveys to explore the acceptability of nuisance species by farmers in Nova Scotia and New Brunswick. Socio-ecological findings related to local knowledge, values, and perceptions of the land and wildlife would provide important data for use in future studies and initiatives for climate mitigation, land usage and conservation partnerships within the region. There are already conservation groups and land trusts that have relationships with local people on the isthmus, including but not limited to the Nature Conservancy of Canada (NCC) and New Brunswick Community Land Trust (Macdonald &

Clowater, 2005). These relationships provide one avenue of joint strategy in a region containing two provincial borders and yet lacking coordinated conservation strategies between NB and NS (Macdonald & Clowater, 2005).

The Chignecto Isthmus Wilderness Area is a recent example of the relationship in NS between private land ownership and conservation efforts: it is a protected area on the isthmus that quadrupled in size in 2017 after land securement but continues to be surrounded by privately-owned land (Nova Scotia Canada, 2017). The original wilderness area was designated in 2008 on lands owned by the nearby Town of Amherst to safeguard the groundwater recharge area for its drinking water supply (Nova Scotia Environment, 2009). This mixture of conservation and private land ownership showcases why it is important to consider human values toward wildlife and knowledge of wildlife species, locations and movement pathways: in-depth insights into critical pathways for wildlife in this narrowing strip of land should (i) contribute to improve strategies and infrastructural adaptation plans that support both human and wildlife movements, and (ii) provide critical information and open lines of communication and collaboration with key local people in the Chignecto Isthmus, fostering and enhancing public knowledge exchange and engagement.

Approximately 30% of the land in Nova Scotia is provincially managed Crown and Public Lands, with about 70% of land being privately held (NS Department of Land and Forestry, 2018). In New Brunswick, 48% of the province is Crown land (NBEN, n.d.), 22% is large industrial freehold, and 30% is privately owned, often by small woodlot owners (Province of New Brunswick, 2016). Moreover, those like farmers who own land in the region often do not own contiguous parcels of it, which has been shown to have an impact on fragmentation of pond and wetland habitats (Sherren & Greenland-Smith, 2019). Along with consideration of different land tenure systems, total areas of landmass, human populations and so forth, the high percentages of private land and fragmented ownership patterns illustrate the necessity of using varied approaches to achieve the goals of biodiversity conservation and wildlife protection in tandem with human needs. The engagement of local people is critical to influence the use of limited Crown and Public lands, as well as private lands. With the variety of individuals, communities, sectors, agencies, and organizations involved, there should be a strong focus on co-management, stewardship, stakeholder, and broad public communication to address the complex issues of wildlife movement across ecosystems on both public and private lands.

The engagement of local people with strong, experiential knowledge of the land and wildlife represents a good place to start in exploring local knowledge, values, and perceptions of wildlife species, locations, and movement patterns. Many of these will be local landowners and will have lived in the Chignecto Isthmus region and experienced the land culturally, socially, economically, and ecologically; they possess tacit knowledge of wildlife locations and movement in the Chignecto Isthmus region, and value wildlife in many ways, due to this lived experience. Local people with strong tacit knowledge represent a resource that has been untapped for years in wildlife research but has been harnessed in research on local perceptions of habitats like wetlands and the landscape implications of responses to climate change (e.g. Chappell et al., 2020; Sherren et al., 2016; Sherren & Verstraten, 2013). There is also recent work examining farmers' attitudes toward biodiversity stewardship initiatives (Sherren et al., 2020) and if participation in stewardship programs impacts farmers' involvement in farming practices that are biodiversity-friendly (Goodale, Yoshida, et al., 2015). These studies do not focus on wildlife movement using spatial means or relational values toward wildlife but are nonetheless relevant in their examinations of larger-picture motivations and attitudes surrounding acceptance of and responses to landscape changes in the region.

There have been significant contributions to the study of wildlife movement and pathway modelling in the region. Macdonald and Clowater (2005) consulted with stakeholders from multiple groups in relation to their views of habitat connectivity and fragmentation in the region about 15 years ago. The modelling completed by NCC in the years since has relied on expert consultations, where expertise has been defined as scientific and academic, rather than as intensive experiential knowledge of the land (Noseworthy, 2014; Nussey, 2016; Nussey & Noseworthy, 2018).

Local people with strong tacit knowledge are likely to be able to provide insights and data that complement existing natural/formal scientific data on complex ecosystems (Berkes, 2004). Previous research has integrated local knowledge with scientific and formal knowledge through processes of co-production (e.g. Ahmad et al., 2021; Ainsworth et al., 2020; Cooke et al., 2016; Olsson & Folke, 2001). Co-production has local knowledge holders involved from the beginning of the project and involves collaboration between researcher and knowledge holder, and this notably improves conservation outcomes (Ahmad et al., 2021; Berkes, 2007). Ahmad et al. (2021) successfully collected information about local species in Borneo using mixed methods

of surveys and spatial data collection, estimating local wildlife densities. Ainsworth et al. (2020) used the process of co-production to help mitigate conservation conflicts in Scottish moorlands, bringing together local knowledge holders and scientists to discuss changes in local focal prey and predator species, the reason for these changes, and if there was evidence of success or failure in current wildlife management processes. The authors found that participating local knowledge holders developed more trust in one another and in the information about predation dynamics, leading to potential conservation conflict alleviation (Ainsworth et al., 2020).

Infusing ecology-driven studies with data obtained from local knowledge holders and integrating a variety of data sources (such as scientifically trained expert data alongside local knowledge expert data), should provide a robust picture of the patterns and issues related to wildlife and connectivity in the Chignecto Isthmus region.

1.2 Thesis objectives

The goal of my thesis research is to delve into local tacit knowledge of and relationship with wildlife, wildlife locations, and movement patterns in the Chignecto Isthmus region. This is done with the purpose of expanding the base of knowledge of regional wildlife through knowledge co-production with these local knowledge holders. The mixed qualitative methodologies for this research are used in ways that reflect and engage the participants' autonomy, agency, and values. To achieve this goal, my objectives are to:

1. Examine how local knowledge holders perceive wildlife, their distribution and movement patterns, changes in these patterns over space and time, and reasons for these changes, and;
2. Examine how local knowledge holders value wildlife and form human-wildlife relationships for better understanding of local values, in order to better inform wildlife conservation measures in the study area.

Findings will contribute to the growing body of work focused on nature conservation in the Chignecto Isthmus in the face of alarming global, national, and regional biodiversity loss and local climate change impacts. They will contribute to the broader field of conservation science by illustrating how local knowledge holders can provide important wildlife insights for conservation planning. More generally, they will help support the rationale for inclusive knowledge systems and the co-production of knowledge in land use and wildlife conservation planning in the study region and other regions with similar social-ecological contexts.

This research is situated within a larger research project funded through the Social Science and Humanities Research Council (SSHRC) Insight Development Grant (K. Beazley, #430-2018-00792), which explores the use of tacit knowledge in mapping wildlife movement pathways through the Chignecto Isthmus. The larger project aims, in part, to generate co-produced, inclusive knowledge for use in planning climate change infrastructural adaptation and other initiatives in the region, enhance human-wildlife coexistence, and more generally help to infuse social science into the field of connectivity conservation (Beazley et al., 2018). Stated objectives of the larger project that are most relevant to my contribution are to:

1. Investigate local/tacit knowledges as a means of mediating formal expert/scientific knowledge, to reveal differences in how experts and local people act as intermediaries to transform the world into referents (e.g., maps and models), conceptually and in the specific geographical setting [Chignecto Isthmus], and;
2. Collect and analyse social science data on human-wildlife interactions, … for comparison and subsequent integration with natural science data (maps and models) (Beazley et al., 2018, p.16).

Within this context, my thesis seeks to capture local knowledge holders' perceptions and values of the Chignecto Isthmus region and wildlife species, distribution, and movement patterns, including changes over time, and the reasons for such patterns. Analyses focus on textual and spatial data gathered through in-depth, in-person semi-structured interviews. The maps used during those interviews serve as intermediary (Latour, 2004) or boundary object (Star, 2010; Star & Griesemer, 1989) and the mapped data help to convey local knowledge holders' perceptions of what they consider to be the location and spatial extent of the Chignecto Isthmus region and wildlife patterns, and serve to convey their own frames of reference for the area for which they have strong experiential/tacit knowledge.

The methodology proposed by Beazley and collaborators for the SSHRC-funded research, includes mixed methods of semi-structured interviews with local knowledge holders, using maps as visual aids and elicitation tools (Phase I), followed by two map-based workshops (Phase II), and qualitative, thematic content analysis of textual and spatial data. Through my thesis work, these methods were further developed, refined, and applied (as elaborated in Chapters 2 and 3). I obtained ethical approval to conduct the research from Dalhousie

University's Social Sciences Research Ethics Board (REB file # 2019-4763). A fellow student, Jessica Needham, and I, as research assistants on Dr. Beazley's project, collected the research data together, conducting interviews with 34 individual local knowledge holders in summer 2019 and two workshops with groups of 10-12 of these same knowledge holders in January and February 2020. Jessica Needham's Master of Environmental Studies (MES) thesis addresses the participatory geographic information systems (GIS) components of this research (Needham, 2021). Her work focuses on the co-production and generation of local knowledge of wildlife locations and movement patterns and its integration with data derived from formal natural science and computer modeling. Together, our research contributes to a growing body of more-inclusive co-produced knowledge of wildlife patterns, human-wildlife interactions, and their complex social-ecological explanatory factors in the Chignecto Isthmus region.

1.3 Geographical and theoretical context

Locating a research project geographically and theoretically is important to better contextualize participants' answers and study findings. It is, therefore, pertinent to firmly situate this research within the region where it took place, and in which the local knowledge holders who are part of this story reside, and to acknowledge pre-existing studies relevant to the topic. As a qualitative researcher, I believe it is also important to ground oneself in the specific geographical place, so as to be more informed and prepared to examine the shared knowledge in ways that are relevant and appropriate to the spatial and sociocultural context (Anderson, 2004). Scholars such as Crang and Travlou (2001), Anderson (2004), and (Casey, 2001) have recognized the importance of geographic space as part of human identity, integral in understanding knowledge in a spatiotemporal context.

In an effort to achieve this, Jessica Needham and I spent our field time in the region, between interviews, debriefs, and transcriptions, exploring the outdoors, with some areas being recommended to us by participants and others being found by us through our own explorations (Figure 1). As not every reader will have the opportunity to visit the Chignecto Isthmus, the following sections describe the region, relevant previous research associated with wildlife movement within the region, and the theoretical context underlying my study within the region. These aim to situate the research, both geographically and academically.

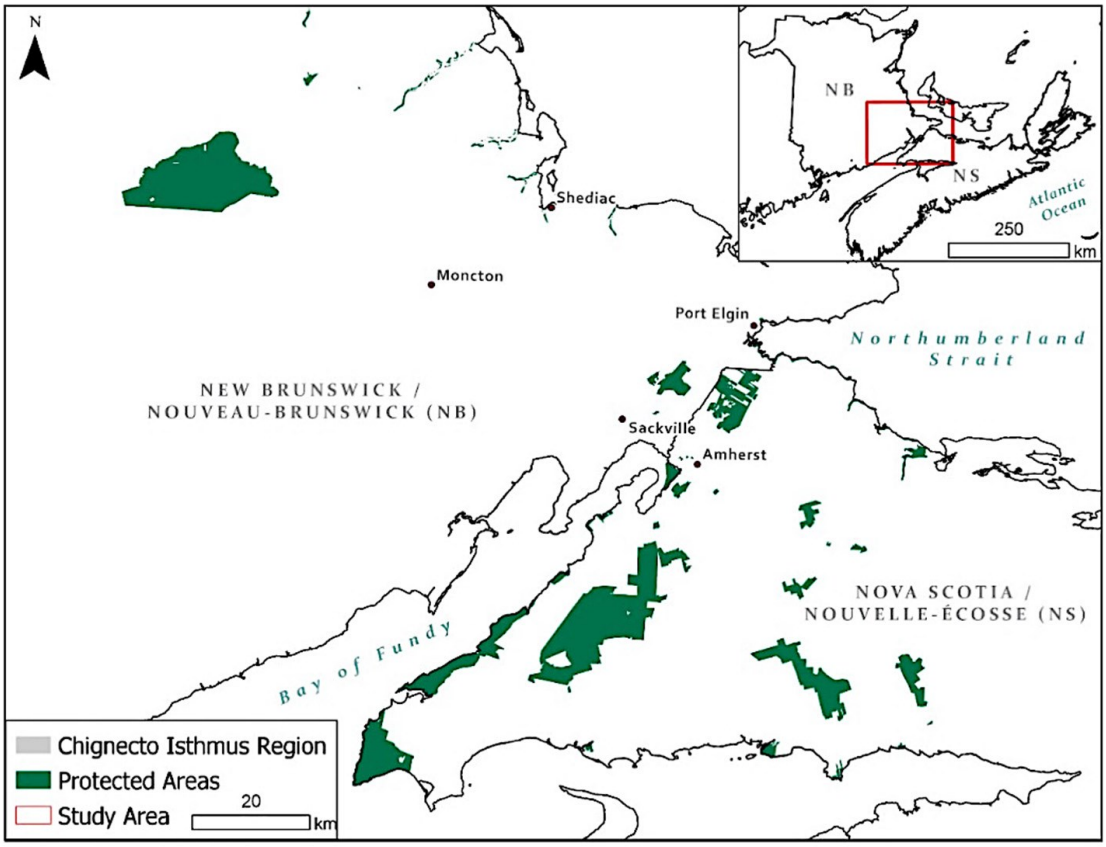
Figure 1. In the field in the Chignecto Isthmus Region

Note. Co-researcher looking out over the Bay of Fundy after we assisted with a local beach cleanup effort on the Bay of Fundy as part of our process of becoming familiar with the study region. Copyright 2019 by Victoria Papuga.

1.3.1 Geographical context – The Chignecto Isthmus Study region

The Chignecto Isthmus is a relatively narrow strip of land, only 24 kms wide at its narrowest point, that provides the sole connection between NS and NB (Figure 2). It is located in northwestern NS and southeastern NB, with the Chignecto Bay (part of the Bay of Fundy) on its southern shore and the Northumberland Strait on its northern shore.

Figure 2 Map of the Chignecto Isthmus study region in NS and NB, Canada.



Note. Reproduced from Needham et al., 2020, as permitted under the Creative Commons Attribution License (https://creativecommons.org/licenses/by/4.0/)

The Chignecto Isthmus is recognized as a significant area for biodiversity and wildlife connectivity (Staying Connected Initiative, 2018; Woolmer et al., 2008; Reining et al., 2006). A key part of its significance is its role as the only land connection by which terrestrial animals may move to and from NS, southeastern NB and the rest of mainland North America, thereby representing a key linkage area at both local and regional scales (Beazley et al., 2005; Nussey & Noseworthy, 2018; Reining et al., 2006; Snaith & Beazley, 2002; Woolmer et al., 2008). Endangered species, such as NS mainland moose (*Alces alces Americana*), require this connection for population viability over both short and long terms, including movements in response to climate changes (Beazley et al., 2005; Snaith & Beazley, 2002). Various initiatives have been focused on this region over the past few decades, mostly initiated by university researchers (Beazley et al., 2005; Webster, Kongwongthai, & Crowell, 2012; Barnes, 2019) and

environmental non-governmental organizations, such as the Wildlands Project (now Wildlands Network) (Reining et al., 2005), Two Countries, One Forest (2C1Forest) (Trombulak et al., 2008; Trombulak & Baldwin, 2010; Woolmer et al., 2008), Canadian Parks and Wilderness Society (CPAWS) (MacDonald & Clowater, 2005), and Nature Conservancy of Canada (NCC) (Nussey 2016; Nussey & Noseworthy, 2018). The NCC and partners have engaged in various initiatives such as the Moose Sex project, citizen science, and roadkill surveys, notably leading its nomination and selection in 2019 as a Community Nominated Priority Place for Species at Risk, one of only 15 in Canada (ECCC, 2019). Recently, NCC has published maps showing the modelled outputs of projected wildlife pathways for a suite of 15 wildlife species through the Chignecto Isthmus, between habitat patches on Nova Scotia and New Brunswick sides of the provincial border (Nussey & Noseworthy, 2016; 2018). Subsequent roadside roadkill surveys along road sections intersecting with NCC's high-probability wildlife pathway for all 15 modelled species combined have helped to verify NCC's model results (Barnes, 2019; Barnes et al., 2020). As part of the Community Nominated Priority Place program, NCC and their partners are engaged in applying the open standards for conservation of species at risk in the region (ECCC, 2019).

The Chignecto Isthmus is also receiving national and provincial attention due to its role as a significant transportation, communication, and energy corridor, given current and impending threats to it from climate change, particularly sea level rise, and flooding. The governments of Canada and New Brunswick have initiated an engineering study focused on mitigating climate change effects on the Chignecto Isthmus Trade Corridor (Government of Canada, 2018). The study addresses concerns about the security of the Trans-Canada Highway and the Canadian National (CN) rail line corridors due to threats from rising sea levels and failing infrastructure, such as centuries-old dikes falling into disrepair (Letterick, 2018). While the focus of that study is on physical infrastructure, the implications of infrastructural adaptations and mitigations for humans and wildlife are potentially significant and warrant attention in their own right (Richard Forman et al., 2003; Thorne et al., 2009).

1.3.2 Previous wildlife connectivity research in the study area

There is no paucity of research and literature identifying the Chignecto Isthmus as a significant wildlife movement corridor in North America (Reining et al., 2006; MacDonald & Clowater, 2007; Woolmer et al., 2008; Trombulak et al., 2008; Nussey, 2010; de Graaf, 2011; Noseworthy, 2014; Nussey, 2016; Nussey & Noseworthy, 2018; Staying Connected Initiative,

2018). The general purpose of these studies was to aid in the identification of key lands needed to preserve structural connectivity in the region and thus represent priorities for conservation measures, such as conservation easements and protected areas, as well as key areas to reduce barriers to movements such as through roadway mitigation strategies. Seminal papers that have analysed connectivity for wildlife locally within the Chignecto Isthmus include MacDonald and Clowater (2005), Noseworthy (2014), Nussey (2016), and Nussey and Noseworthy (2018). The latter three studies comprise a sequential and cumulative body of work that represents cornerstone natural-science-based models that our research aims to complement and enrich by generating and sharing local experiential knowledge.

Initially, MacDonald and Clowater (2005) analyzed and modelled connectivity on both sides of the border, looking at human developments and activities, such as roads and forestry activities, cutting off movement and funneling wildlife into a smaller corridor as far into NS as Truro. Their comprehensive report considers the history of the region, local wildlife knowledge, land cover classes, riparian corridors and modeled wildlife pathways and pinch points across diverse landscapes. The report was co-published by NS and NB chapters of the Canadian Parks and Wilderness Society (CPAWS) to increase understanding of connectivity issues in the region. Species used in modelling were selected on the basis of those indicated in the literature and in interviews with local residents, university faculty members, members of local organizations such as the Cumberland County River Enhancement Association, conservationists, hunters, and biologists. By mapping regional roads, applying road buffers and delineating larger patches of remaining intact habitat as compared to more heavily fragmented areas, MacDonald and Clowater illustrated possible wildlife movement pathways throughout the region and identified high priority areas for wildlife connectivity.

The three modelling studies by Noseworthy (2014), Nussey (2016), and Nussey and Noseworthy (2018) were supported and published by the NCC with funding from the NB Wildlife Trust Fund and Nova Scotia Habitat Trust Fund. Noseworthy (2014) modelled least-cost wildlife movement pathways for a suite of focal species in NB, between the border with NS and the Canaan Bog Protected Natural area in NB. Nussey (2016) expanded on this work by modelling pathways on both sides of the NB-NS border within the Chignecto Isthmus region. Nussey and Noseworthy (2018) refined and continued the work, modifying it “to capture a broader range of terrestrial habitat requirements” (p.2). Each of these studies used linkage mapper software

(McCrae & Kavanaugh, 2014) for ArcGIS 10 to model least-cost wildlife pathways across the landscape, identifying corridors where they converged using Kernel Density modelling, generating map outputs of high-probably wildlife movement corridors. The movement corridors were narrower on the NB side, with paths diverging on the NS side. A pinch-point, or bottleneck, of movement is noted at the NB-NS border where movement is essentially "funneled" into a narrow corridor that is only 5 kms wide. While the Nussey and Noseworthy (2018) report built on previous studies, it was the first of its kind to "attempt to capture structural connectivity based on the specific habitat requirements of focal species for the entire cross border Chignecto region" (p. 11).

By highlighting previous work to identify wildlife movement corridors, this project may be further contextualized and grounded. It is also important to acknowledge that researcher bias exists in the realm of wildlife movement mapping, whether it is done by computer modelling or by tacit knowledge holders. In the case of computer modeling studies, the movement corridors are dependent on the species chosen by each researcher as are the habitat parameters, and these may be different between models if different resources to identify the species and parameters are used. In the case of modelling wildlife movement pathways across the Chignecto Isthmus similar species and parameters have been used, with subsequent research drawing on the previous methods and results to improve the likely accuracy of the pathway modelling.

1.3.3 Previous research at broader provincial and ecoregional scales

The above-cited modelling studies and research reports focus on habitat connectivity and wildlife movement in the Chignecto Isthmus region. Although those are the most directly relevant to this thesis, there are other studies that address broader provincial and regional patterns of connectivity (Trombulak et al., 2008; Woolmer et al., 2008; Reining et al., 2006). Through both focal species population modelling (Beazley et al., 2005; Snaith & Beazley, 2002) and landscape connectivity modelling (Reining et al., 2006), these studies have consistently identified the Chignecto Isthmus as critical to wildlife movement yet vulnerable to fragmentation. Taken together, this body of work has established the necessity of habitat connectivity conservation through the Chignecto Isthmus area as a priority linkage area for wildlife movement at local, provincial, and ecoregional scales.

Based on early research at Dalhousie University, the importance of the Chignecto Isthmus for recovery of wide-ranging species-at-risk in Nova Scotia was flagged. For example, when applying population viability theory to populations of the endangered mainland moose (*Alces alces americanus)* in Nova Scotia, Snaith and Beazley (2002) came to the conclusion that their long-term viability would require habitat connectivity into NB. Beazley et al. (2005) later identified core areas of habitat and corridors for three focal species (American marten, American moose, and Northern goshawk), identifying the same pinch point on the Isthmus as later found in MacDonald and Clowater (2005), Noseworthy (2014), Nussey (2016), and Nussey and Noseworthy (2018).

Research conducted by the Science Working Group of a non-governmental, cross-border Canada-United States consortia called Two Countries, *One Forest* (2C*1Forest*) identified priority areas for conservation in the Northern Appalachian – Acadian ecoregion, including critical linkage areas (Trombulak et al., 2008; Woolmer et al., 2008). It built upon earlier work by the Wildlands Project (now Wildlands Network) (Reining et al., 2006), in which a "wildlands network" was delineated for the ecoregion, identifying core and connectivity areas for conservation, including through the Chignecto Isthmus. Through this work, the Chignecto Isthmus was identified as a priority linkage area within the larger ecoregion, which that spans eastern Canadian provinces and states within the United States. Woolmer et al. (2008) mapped the human footprint for the ecoregion, gauging the influence human presence and activities, and showing areas of habitat fragmentation in the Chignecto Isthmus region (Woolmer et al., 2008), which have been further exacerbated in the decades since.

The Staying Connected Initiative (SCI) was formed soon after, in 2009, with the aim to strengthen partnerships and collaborative initiatives to protect and maintain habitat connectivity across the ecoregion, in both Canada and the United States (Hawk, Miller, Reining, & Gratton, 2012). SCI has focused on priority linkage areas as identified by 2C*1Forest* (Trombulak et al., 2008; Woolmer et al., 2008), including the Chignecto Isthmus. Later, Coker and Reining (2013) provided a baseline for measuring connectivity in the ecoregion; Trombulak et al. (2013) identified past, present and future opportunities for conservation initiatives in the region; and Perkl, Baldwin, Trombulak, and Smith (2016) compared the efficacy of various wildlife movement corridor models and how these may align with conservation scenarios in the region.

Together, these studies represent substantial contributions of researchers, organizations, conservationists, and other partners to the field of habitat connectivity mapping and planning. For the most part, however, they do not incorporate local tacit knowledge (with some exception in Reining et al., 2006) and all stress the lack of data for effective assessment of wildlife distributions and movements and for verifying the modelled results in the region. This is where our research with participating local knowledge holders come in.

1.3.4 Theoretical context

The Chignecto Isthmus region is a social-ecological system (SES). As defined by Anderies et al. (2004), an SES is an "ecological system intricately linked with and affected by one or more social systems" with a "combination of systems that contain interdependent units" (p. 2). These are systems that are dynamic and "constantly changing" (Schluter et al., 2014, p.1). Social-ecological systems contain different systems nested within one another; local ecosystems are nested within larger and regional ecosystems, while management practices are nested within institutions and larger, nested institutions (Colding & Barthel, 2019). The ecological (i.e. the ecosystem) and the social (i.e. management practices and larger social human dynamics) interact and react to each other, with ecological knowledge and understanding acting as a critical link in forming the SES (Folkes & Berkes, 1998; Colding & Barthel, 2019). In our research, we have focused on the ecological knowledge of local knowledge holders in a local-regional context, as the ecological context of wildlife and environment interplay with the social dynamics of local human systems.

Humans are active forces in the social and ecological systems of an SES; the agency to make choices that guide action is an integral part of the human experience (Bandura, 2018). Humans have the agency to guide and decide how they will interact with their environment, shaping human-wildlife and human-environment experiences (Wolf et al., 2013). It is through this agency that land inhabitants and users create and develop relationships with the land, wildlife, and fellow humans. In our research, we sought to embed room for participant agency within our methodologies and employ it in interactions with participants. Providing for agency in methodologies is important in that it avoids planting ideas that may bias the results. For example, the semi-structured interview format and interview guide with open-ended questions allowed for the dialogue to progress and evolve, while the maps acted as a gateway to conversations between researchers and participants. These maps often acted as a mediator

(Latour, 2004), allowing for the participants to express their knowledge in their own way with the ability to choose which spatial and temporal scale(s) they were most comfortable expressing their knowledge through. Maps were, in essence, boundary objects through which local knowledge holders were able to express their tacit knowledge in a concrete manner jointly understood by both participant and researcher (Edwards et al., 2019).

Agency allows for participants' responses to be constructed through their experience with the region and influenced by the physical characteristics of the region, as shown by Stedman (2003). Conceptualisations such as Canter's (1991) assert that people need to have the agency to claim their own settings, including spatial scale-related issues, rather than simply having agency within researcher-defined settings. A crucial aspect of participants' agency is in the active construction of their setting (Jorgensen & Stedman, 2011). Accordingly, we did not explicitly delineate the boundaries of the study area - the Chignecto Isthmus or the Chignecto Isthmus Region – and we did not identify or name specific species that participants should talk about as wildlife; we did not ask about particular areas within the study area, and we provided maps at various spatial scales, to offer a choice to participants. Through these purposive ambiguities and openings embedded within the research methodologies we wanted to see what the participants voluntarily came up with: what values and conceptions of wildlife they first expressed; their perceptions of the region; as well as their primary lived experiences on the land and relationships with the land. We wanted to know, given the agency to choose, what would participants decide to talk about? What would they choose to show us on the maps? And, furthermore, what would this information then tell us about what they think about the 'region' as they see it, and about wildlife, their movement patterns and changes over time? How is this information conceptualized in terms of i) wildlife species, ii) wildlife movement, iii) barriers and opportunities for movement, iv) changes to movement, v) the scale of movement and of the 'region' itself? And, importantly, how do our participants interact with, relate to, and value wildlife?

How humans frame their interactions with wildlife is influenced by how humans value wildlife. Is one species of wildlife deemed a pest because it impacts another species utilized by human hunters? Or, is the interaction between human and species viewed as a good omen, stirring positive emotions? Through understanding how participants relate to and value wildlife, I hope to find the common threads and key differences among local knowledge holders that

may be harnessed to illuminate the relationships between humans and wildlife in the region, especially positive ones, thus informing effective conservation strategies. To understand these values, I use Kellert's (1996) framework of wildlife values to examine the human-wildlife relational values in the region. Kellert's framework has been used for decades to explore values toward wildlife and the environment, with the associated body of empirical evidence in the literature demonstrating its utility in exploring these values (e.g. Kellert, 1991; Reading et al., 1999; Auster et al., 2009; Kahn et al., 2002; Ross et al., 2018; Witt et al., 2019). Understanding values toward wildlife provides a nuanced understanding of the human dimensions of wildlife conservation research and management, going beyond sociodemographic identities and their associated stereotypes (e.g. the hunter only caring about their own consumption) (Teel & Manfredo, 2010). I use Kellert's framework to examine the values expressed toward wildlife and the wider environment of the Chignecto Isthmus region by local knowledge holders, interpreting the nuances in their responses for a better understanding of how they feel toward wildlife and what informs these feelings, relationships and valuations. Accessing local knowledge and values toward wildlife is an important step in facilitating human-wildlife coexistence (Teel & Manfredo, 2010).

Overall, I am interested in exploring what meanings can be derived regarding local perceptions of wildlife patterns and relational values in terms of enhancing conservation of wildlife in the region. How do these social-science derived findings help us to understand and inform wildlife conservation and human-wildlife coexistence, including aspects such as road mortality mitigation, connectivity planning, land conservation, forestry practices and climate change?

1.4 Thesis structure

This thesis aims to explore the perceptions, values, and tacit knowledge that local people with strong experience of the land and wildlife hold in connection to wildlife within the Chignecto Isthmus area, using social science methodologies, adding to the field of conservation science with pertinent social science research. It is organized into four chapters, two of which present distinct, yet core, aspects of the thesis. These are flanked by two supporting chapters that set the stage and synthesize the work and draw summary conclusions. In this first chapter, I have introduced the research, justifying its purpose, situating it within its broader context, and providing a foundation of support within the literature. Chapter 2 presents a co-authored,

published paper that provides methodological details of the project and explores how local knowledge holders frame their perceptions of wildlife, their movement patterns and the issues they face in the region, using mapped outputs. Because it was published as a stand-alone paper, some repetition of key content occurs. Chapter 3 delves into the relational values participants expressed toward wildlife using Kellert's (1996) wildlife values framework, exploring the diversity of these expressions, and how understanding them is important for effective biodiversity conservation. Chapter 4 provides a synthesis discussion and summary conclusion. It is the capstone chapter, addressing how the research objectives have been achieved, interpreting the findings in relation to the relevant literature, identifying limitations and further research opportunities, discussing the potential contribution of the findings to on-the-ground conservation initiatives in the region, and considering the potential application of our methods in other regions that are impacted by landscape development and climate change, yet essential to human-wildlife coexistence. Together, these offer place-based research that adds to a growing appreciation for and understanding of human-wildlife relations and its role in conservation.

CHAPTER 2 - Accessing Local Tacit Knowledge as a Means of Knowledge Co-Production for Effective Wildlife Corridor Planning in the Chignecto Isthmus, Canada

This chapter was published on 20 September 2020 in the journal, Land (9: 332; DIO: 10.3390/land9090332). Authors are Jessica L. Needham, Karen F. Beazley and Victoria P. Papuga. My contributions to the research and the writing of the paper include: assisting with the development of the project; securing research ethics approval (REB file # 2019-4763); developing the interview guide; collaborating in the recruitment of participants and in conducting the interviews; collaboratively planning and facilitating the workshops; analysing textual data from interview transcripts and workshop notes; assisting with the identification of emergent spatial data themes; and, assisting with writing and editing the paper, including identifying key quotes from participants on social-ecological systems and sea-level rise.

In the context of my thesis, this chapter addresses my first research objective: examine how local knowledge holders perceive wildlife, their distribution and movement patterns, changes in these patterns over space and time, and reasons for these changes.

2.1 Introduction

Connected systems of effectively protected and conserved areas are considered critical to addressing both biodiversity and climate crises (Hilty et al., 2012; Woodley et al., 2019 a,b; Worboys et al., 2016). Ecological connectivity allows for genetic flow and is imperative to maintaining natural ecosystem processes (Watkinson & Sutherland, 1995). Discontinuous and fragmented habitat can restrict the movement of wildlife and gene flow with adverse effects on populations and the persistence of species (Caprio 2001; Beazley et al., 2006;). Connectivity facilitates genetic exchange among subpopulations (Beier 1993; Brussard 1985; Reed et al. 1986; Soulé 1980), helping to maintain genetic diversity and metapopulation viability (Fahrig and Merriam 1994, Beissinger and Westphal 1998), which support species resilience to changes such as disease and climate (Haig, 1998; O'Brien 1994; Wayne et al. 1992; Krosby, Tewksbury, Haddad, & Hoekstra, 2010). In the face of climate change, ecological connectivity is considered crucial to species adaptation strategies (Chen et al., 2011; Heller & Zavaleta, 2009)As temperatures rise, connectivity can enhance the ability of species to move in response to range

shifts by utilizing ecological corridors (Krosby et al., 2010; Chen et al., 2011; Lawlor et al., 2013; McGuire et al., 2016).

Given the importance of connectivity, and on-going threats to it, conservation measures are warranted to maintain and restore key ecological corridors (Hilty et al., 2020; Hodgson et al., 2011; Worboys et al., 2016). With competing demands on a limited land base, however, any plans for additional protected or conserved areas need to be grounded in rigorous evidence and supported by local people (Margules & Pressey, 2000; Groves et al., 2002; Pressey et al., 2015; Reed et al., 2015). Conservation issues are multi-faceted and involve complex social and natural systems that require both the natural and social sciences to solve (Virapongse et al., 2016a). For effective conservation decision-making processes to occur, there must be a mobilization of diverse knowledges and ways of knowing. Knowledge systems that combine social and natural sciences, including local perspectives, are often difficult to generate and mobilize (Cvitanovic et al., 2015; Cvitanovic, McDonald, & Hobday, 2016; Nguyen, Young, & Cooke, 2017; Segan, Bottrill, Baxter, & Possingham, 2011; Sutherland et al., 2012). Yet, the importance of local and inclusive knowledges in conservation planning is increasingly recognized (Bennett & Roth, 2015; Cvitanovic, Cunningham, Dowd, Howden, & van Putten, 2017; Fazey et al., 2013).

This paper accesses and generates local tacit knowledge of wildlife locations, movement patterns and landscape features that represent opportunities and barriers for connectivity conservation planning. The study area is the Chignecto Isthmus, a primarily rural region that serves a critical landscape linkage function in the eastern Canadian provinces of Nova Scotia (NS) and New Brunswick (NB). While the local findings and outcomes are important in their own right, the work contributes to the growing body of conservation planning literature that demonstrates the value and utility of local tacit knowledge as complementary, accurate information for decision-making in diverse contexts. The generation of local experiential knowledge in study regions where formal natural-science data and resources are sparse may represent a particularly important source of relevant data to address data gaps, validate or ground truth modeling studies and weave in important social and ecological knowledge particular to the place and people. Even in areas where formal science data are available, the engagement of local people and their tacit knowledge is important to opening up research to different ways of knowing, breaking down western-scientific notions of science and whose information counts. At the same time, inclusion in the research process may increase awareness

and potentially mobilize locally influential participants to engage in associated planning and management initiatives. In our case, the research process may foster consideration of wildlife and key wildlife movement pathways in government efforts to identify engineering solutions to protect infrastructure from sea-level rise and engagement in on-going collaborative wildlife conservation initiatives in the Chignecto Isthmus.

The Chignecto Isthmus is a narrow strip of land (currently ~25 km in width, ~19 km as dry land) that connects NS and southeastern NB to the rest of mainland North America. It is threatened by sea-level rise (Desplanque & Mossman, 2004; Parkes et al., 2006; Rahmstorf, 2007), storm surges and flooding (Greenberg, 2001), along with increasing human developments such as roads, railways, energy and communication infrastructure (CBCL Limited, 2009; Tim Webster et al., 2012). Effective mechanisms to conserve wildlife movement patterns are critical to biodiversity conservation and climate resilience and adaptation for species in this region. Although previous conservation planning studies have identified the region as of critical importance to species at risk and broader ecological connectivity (Beazley et al., 2005; Woolmer et al., 2008), there have been relatively few empirical and spatial analyses. Most assessments of wildlife habitat and connectivity have been based on computer-based models (Macdonald & Clowater, 2005; Nussey, 2016; Nussey and Noseworthy 2018), often at larger provincial and eco-regional scales (Beazley et al., 2005;Reining et al. 2006; Woolmer et al., 2008). In their 2005 study, Macdonald and Clowater noted that scientific knowledge of local species distribution in the region is lacking, making it difficult to assess habitat connectivity. This situation remains at present. Wildlife monitoring and management by provincial government agencies is not coordinated across NS and NB and the empirical wildlife data that do exist remain provincially specific and not readily accessible or compatible for application across the Chignecto Isthmus region (Macdonald & Clowater, 2005). Recent predictive modelling by the Nature Conservancy of Canada (NCC) has identified high-probability wildlife movement pathways between protected areas in the region, with the recognized need for model verification and further study of identified 'pinch points' to assist in future land management and conservation in the region (Nussey, 2016; Nussey and Noseworthy, 2018). Some model validation has occurred through roadside surveys of wildlife roadkill (Barnes et al., 2020; Barnes, 2019). Capacity for wildlife research is limited in the area, with a lack of financial and other resources for field studies across the entire region.

To date, regional efforts to mobilize knowledge have largely focused on natural science and nature conservation, rather than on local tacit experience and perceptions. Yet, local forms of knowledge and ways of knowing are as important as those generated through formal natural sciences and models. It is likely that there is a strong base of knowledge of the land and wildlife in the region, given long-standing traditions, livelihoods and pastimes associated with living off the land, seasonal hunting, trapping, and fishing in the area and other natural resource uses. Indigenous peoples—the Mi'kmaq—have lived here, in their ancestral and unceded territory — Mi'kma'ki, for 15,000 years and Euro-American settlements began in the 1600s.

Realizing that human factors have been largely neglected in conservation science (Bennett et al., 2017; Brown & Raymond, 2014; Charnley et al., 2007; Failing et al., 2007; Gruby et al., 2015; Raymond et al., 2010), our work aims to enhance the generation and use of local tacit knowledge for connectivity conservation planning and broader norms of human-wildlife co-existence in the Chignecto Isthmus. More specifically, our study seeks to address the data gaps and limitations by engaging in participatory research with local knowledgeable people as a means of garnering important insights on wildlife habitat locations and movement patterns that are likely not adequately represented in the existing empirical and spatial data. At the same time, we hope to enhance the participants' support and engagement in conservation planning initiatives. In doing so, we aim to contribute to a more inclusive knowledge system and capacity base for potential infusion of local knowledge into conservation and other land planning initiatives in the region. Beyond the study area, our research contributes to the growing body of literature related to conservation planning, particularly for wildlife connectivity conservation and the use of public participatory geographic information systems (PPGIS).

2.1.1 The Chignecto Isthmus in context

The Chignecto Isthmus is a unique study region as it plays a critical role in landscape connectivity (Beazley et al. 2005; Macdonald & Clowater, 2005; Reining et al. 2006; Trombulak et al. 2008) (Figure 1). Recognized nationally and internationally as a high priority corridor, both for wildlife movements and linear human infrastructure such as roads, railways and energy pipelines, this region is key to maintaining connectivity between NS, southeastern NB and continental North America (Hilty et al., 2012; Lemmen et al., 2016; Nussey & Noseworthy, 2018). Its ecological importance is recognized through its designation as one of Canada's 15

Community-Nominated Priority Places[1] (Environment and Climate Change Canada, [ECC], 2019). Enhanced local awareness of its role in species' population persistence has been raised through NCC's 'Moose Sex' project (Holland, 2014; The Nature Conservancy of Canada, 2012). Several challenges emerge, however, in understanding, maintaining and restoring connectivity for wildlife and other ecological processes through this narrow region, particularly in the context of a complex network of roads and other human infrastructure. Bounded by the Northumberland Strait and the Bay of Fundy, the Isthmus is fragmented by seven two-lane roads that transect the region (Macdonald & Clowater, 2005; Barnes et al. 2020), and the Trans-Canada Highway and the Canadian National Railway that transverse the region (Mackinnon & Kennedy, 2008; Tim Webster et al., 2012).

Sea-level rise (Parkes et al., 2006; Rahmstorf, 2007), storm surges, and flooding (Greenberg, 2001; Shaw et al., 1998) threaten terrestrial connectivity across the Isthmus, compounded by habitat loss and fragmentation (CBCL Limited, 2009; Tim Webster et al., 2012). Drivers include urban and rural development; transportation, energy and communications infrastructure; forestry and agricultural activities; and climate change (Lemmen et al., 2016; Macdonald & Clowater, 2005; Woolmer et al., 2008). At times, historically and during the Saxby Gale in 1869 (Abraham et al., 1999; Parkes et al., 1997), the Isthmus has been inundated with waters from the Bay of Fundy (Desplanque & Mossman, 2004; Peltier, 2004). Storm surges funnel up the Bay of Fundy—a dynamic marine system with the highest recorded tides in the world (16.3 m)—culminating in the Chignecto Bay (Desplanque & Mossman, 2004; David Greenberg et al., 2012b; Shaw et al., 2010). The elevation of the entire region is less than 90 m above sea level and is dominated in the southern region by low lying salt marshes, wetlands and bogs (Macdonald & Clowater, 2005). Beginning with French Acadian settlement in the late 1600s, large areas of salt marsh were transformed into dykelands for agricultural use (Butzer, 2002; Shaw et al., 2010).The northern portion of the region is at higher elevation and relatively

[1] NS and NB – 'A community of practice to protect and recover species at risk on the Chignecto Isthmus': Nature Conservancy of Canada and partners (e.g., Birds Canada, Community Forests International, Fort Folly Habitat Recovery Program, Confederacy of Mainland Mi'kmaq - Mi'kmaw Conservation Group) aim 'to build and strengthen community relationships, develop a conservation plan, build public awareness and deliver programs benefiting species at risk. The project will benefit 20 listed species at risk…and 20 additional species of concern. It will occur in the Chignecto Isthmus region of both Nova Scotia and New Brunswick, covering 739,596 hectares.' (ECCC, 2019)

better drained, supporting mixed forests (Macdonald & Clowater, 2005). Higher elevations also occur towards the Northumberland Strait, rated by Canada's Climate Change Impacts and Adaptation Program as of 'medium' sensitivity to sea-level rise compared to areas of 'high' sensitivity in the Isthmus' southern portion (Lemmen et al., 2016).

Projected sea-level rise[2], extreme weather events and storm surges threaten to breach the dykes, flooding parts of the Isthmus including the towns of Sackville, NB and Amherst, NS (CBCL Limited, 2009; D A Greenberg, 2001; Parkes et al., 2006; Rahmstorf, 2007; T Webster et al., 2012). Over the past two centuries, major storm events have breached the dykes and caused extensive flooding around the perimeter of the Bay of Fundy (Webster et al. 2012). Flooding threatens the Trans-Canada Highway and the Canadian National Railway, which move an estimated 50 million CAD per day in trade (Lemmen et al., 2016; Webster et al., 2012), potentially causing detrimental economic impacts (Smith, 2020). As climate change adaptations become necessary, human infrastructural demands could put increased adverse pressures on wildlife habitat across a narrow five-kilometer-wide strip of higher elevation land at the NS-NB border (Nussey & Noseworthy, 2018). Further fragmentation of habitat would restrict the movement of wildlife, with negative consequences for the persistence of populations of wide-ranging, sensitive and vulnerable species (Beazley et al., 2006). Alternatively, carefully planned adaptation measures could potentially provide opportunities to mitigate barriers and pinch points to wildlife movements. Conserving connectivity would facilitate geneflow between subpopulations of species, helping to maintain genetic diversity and species resilience in response to climate and other changes (Beazley et al., 2006).

NCC's recent predictive modelling (Nussey & Noseworthy, 2018) of high-probability wildlife movement pathways in the region may serve to identify priority areas for conserving

[2] An average of tide gauge records at Saint John, NB, estimates sea-level rise as 22 cm over the past century in the Bay of Fundy. This suggests that the current level is approximately 32 cm higher that at the time of the Saxby Gale when a storm surge breached the dykes, causing flooding that temporarily severed NS from NB (Webster et al. 2012, p. 9). Historic trends and modelled projections show that even in the absence of climate change an increase in tidal high water in the order of 0.3 m can be expected in the Bay of Fundy over the next century. Combined with the influence of climate change, "high water in the Bay of Fundy is predicted to rise on the order of 0.5 m over the next 50 years, and on the order of 1 m by the end of the century" (Greenberg et al. 2012, p. 274).

connectivity. They modelled habitat suitability and least-cost-paths for 15 terrestrial species*3* selected to capture a range of territory sizes and habitat requirements[3]. Their analyses identified routes predicted to require the least energetic cost, providing the lowest risk to mortality, thereby minimizing risks to movement among habitat patches between five protected areas in NS and NB. The predictive modelling of potential corridors and pinch points has provided key information for future land management and conservation in the region (Nussey & Noseworthy, 2018). Subsequent roadside surveys and roadkill hotspot analyses have helped to validate some of the model outputs (Barnes 2019; Barnes et al., 2020). Yet, further validation and consideration of areas outside of modeled and field-surveyed sites are warranted.

At the same time, there are increasing pressures to protect human infrastructure in the Chignecto Isthmus from impacts of climate change. In January 2020, the Province of NB sought professional assistance to explore climate mitigation solutions for the transportation corridor (Fournier, 2020). An engineering firm is leading, with the Provinces of NB and NS and the federal government, a 700,000 CAD feasibility study, with the aim to design engineering adaptations that are resilient to climate change and protect the trade corridor by preserving roads, dikes and infrastructure (Tutton, 2019). A previous cost-benefit analysis of adaptation measures to mitigate the impacts of sea-level rise and storm surges included scenarios of reinforcing and raising dykes and barricades, building new dykes further inland, and relocating and re-routing current transportation routes (Parnham et al., 2016). The need to 'engineer' new 'solutions' provides a potential opportunity to infuse an ecological lens into the mix, such as by considering opportunities for maintaining wildlife connectivity. It is imperative to identify and accommodate critical areas of ecological significance, especially if there is the need to relocate infrastructure and mitigations that could impact wildlife, positively or negatively. Critical areas should include pathways that are important to wildlife, as the Isthmus plays an essential role in not only trade and transportation but wildlife connectivity between the provinces. Successful implementation of any such conservation solution or initiative, however, will require political support, including engagement and buy-in by local communities.

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3 The 15 focal species chosen for the NCC Chignecto Isthmus connectivity analysis included: Moose, Black Bear, Red Fox, Bobcat, Snowshoe Hare, Fisher, Northern Flying Squirrel, Barred Owl, Northern Goshawk, Pileated Woodpecker, Yellow Warbler, Brown Creeper, Ruffed Grouse, Boreal Chickadee and Blackburnian Warbler (Nussey & Noseworthy, 2018)

2.1.2 Conservation planning and local knowledge

Over the past 20 years, there has been a shift in the way science has been used in conservation planning (Groves et al., 2002; Margules & Pressey, 2000), recognizing the importance of considering social factors along with ecological ones (Mascia et al., 2003). The social and natural sciences are now seen as complementary, with the challenges now being how to bring them together without privileging one over the other and how to infuse them into conservation planning and practice (Mascia et al., 2003; Bennett & Roth, 2015; Bennett et al., 2017). As such, conservation planning has begun to draw on transdisciplinary approaches from human geography, social ecological systems, PPGIS and others. Such concepts are commonly applied in mapping and modeling studies of human-environment relationships, such as spatial patterns of land use and land cover (Bennett et al., 2017). Core principals are that conservation efforts ought to be systems oriented and cognisant of dynamic social-ecological interconnections between humans, culture, wildlife and ecosystems that are influenced by broad scale forces such as political, economic and biogeochemical conditions (Bennett & Roth, 2015a; Bentley Brymer et al., 2016; Karimi et al., 2015; Ostrom, 2009;Virapongse et al., 2016). Ideally, both society's and science's perceptions of conservation issues should be collaboratively considered (Brown et al., 2010; Fry, 2001; Reyers et al., 2010; Virapongse et al., 2016). As such, conservation planning is challenged to apply innovative models through engagement of diverse communities, facilitate co-learning about conservation and derive solutions through the co-development of knowledge and practice (Bennett, Roth, Klain, Chan, Christie, et al., 2017; Fox et al., 2006; Jacobson & Duff, 1998). Accordingly, there is a growing interest in engaging local people and diverse knowledges to help interpret, frame, verify[4] and otherwise complement knowledge gained through formal natural science methods, including addressing its gaps and limitations (Anadon et al., 2009; Close & Hall, 2006; Loftus & Anthony, 2018).

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4 Terms such as 'validate' and 'verify' can be contentious when talking about bringing together formal science and local tacit knowledge. Such words can imply a privileging of one form of knowledge over the other in terms of veracity, value, etc. What we mean by 'verify' is a form of 'ground truthing' based on local experiential and tacit knowledge, to identify areas of agreement and disagreement, which may then be further explored. In light of such concerns, we at times use 'verify' and at others 'ground truth', although we have not done ground checks in the field.

There is ongoing debate about the use of the term knowledge 'integration', referring to the inclusion of both local knowledge and scientific knowledge within environmental management (Gray, 2016), with important relevance for conservation planning. While the value of including local knowledge has been acknowledged, studies focused on knowledge 'integration' can struggle with considering which forms of knowledge are being privileged, sometime favouring scientific over local knowledge (Raymond et al., 2010). Differing epistemological beliefs about what and how things are known may constrain researchers' abilities to engage fairly with the process of integration (Gray, 2016; Raymond et al., 2010). Challenges may also arise with distrust among researchers and local knowledge holders and through institutional power dynamics and privilege (Gruby, Gray, Campbell, & Acton, 2015; Raymond et al., 2010). Such issues are inherent in attempts to 'validate' local or traditional knowledge with science. The desire to validate can derogate the legitimacy of local tacit and experiential knowledge, especially when the forms of knowledge and ways of knowing derive from fundamentally different epistemological systems, such as with traditional and scientific knowledge (Matsui, 2015; Widdowson & Howard, 2008). To acknowledge and address these challenges and barriers, conservation planning approaches are needed that facilitate the co-production of knowledge, engage more inclusive knowledge systems, and represent different forms of knowledge.

Connectivity conservation is a subset of conservation planning in which inclusive and collaborative efforts are particularly necessary, as it aims to address the conservation of public and private lands and Indigenous territories between protected areas (Wyborn, 2015; Hilty et al., 2020; Zurba et al., 2019; Artelle et al., 2019). The broader landscape is often highly contested space, with multiple demands and claims over a limited land base. Nonetheless, it is important to maintain and restore connectivity across human-dominated landscapes because habitat fragmentation is a key cause of wildlife decline (Hilty et al., 2020). Linear human developments such as roads are increasingly recognized as predominant impediments to habitat connectivity (Forman, Sperling, Bissonette, & Clevenger, 2003; Forman et al., 2003; Fudge, Freedman, Crowell, Nette, & Power, 2007; Robinson, Duinker, & Beazley, 2010; Spanowicz & Jaeger, 2019). Yet, there are few studies that address wildlife and linear development patterns at broad-regional scales, despite calls for such attention (Bager & da Rosa, 2010; Gerow et al., 2010; Thorne et al., 2009; van der Ree et al., 2011). There is also growing recognition that, particularly in coastal areas, responses to sea-level rise will require adaptation measures such as

relocations of linear and other infrastructure from low-lying areas to higher elevations, with potential risks of further incursions into wildlife habitat and disruptions to wildlife movement patterns with implications for population persistence. In order to protect and maintain ecological connectivity, appropriate conservation planning strategies must be developed at local, regional, and national scales underpinned by an understanding of species distribution, barriers to movement and threats to their persistence, consideration of the complex social-ecological contexts and broad support of local people.

Given the challenges inherent to considering multiple, diverse layers of natural and social information and landscape spatial patterns in conservation planning, computer-based GIS are often used to facilitate data compilation and analyses (Bentley Brymer et al., 2016; Sieber, 2006). The mapped outputs of such analyses are powerful tools for communication and decision support, yet they are strongly influenced by the choices of input data and the rules around interpreting it, such as in setting goals and targets for conservation modelling. These technologies, data sets and decisions about objectives and rule-setting have been dominated by the formal natural sciences. To make these systems more inclusive and transparent, PPGIS approaches have been developed (Lovett & Appleton, 2008). While helping to democratize the planning process and enrich the data, questions remain as to how best to reach consensus and how to accommodate and incorporate differences in knowledges and values (Brown & Kyttä, 2018). Methodologies for representing differences and building consensus in participatory mapping are needed. This is especially important given that including local knowledge in planning and decision-making is always troubled with questions of whose knowledge is included and privileged (Gray, 2016; Matsui, 2015; Raymond et al., 2010). The idea of a homogenous community has been deeply critiqued in the literature, and PPGIS methods provide an interesting model for engaging multiple viewpoints without assuming sameness in a local community (Orban, 2011). Distinct from building consensus among diverse stakeholder groups, managers and planners, the question arises as to how to build consensus 'within' distinct groups, such as among local knowledge holders engaged in a participatory mapping exercise.

While the infusion of local perspectives and uses of participatory mapping have expanded over the past two decades (Brown & Kyttä, 2014; Joa et al., 2018; Loftus & Anthony, 2018), there has been relatively little uptake in its application to wildlife connectivity planning. Local knowledge provides a key tool for understanding the complex social and ecological

systems in which conservation planning operates and for which solutions are increasingly coming from models that are unconnected to local people and place. The Chignecto Isthmus provides a study area where conservation planning is not only imperative for maintaining local wildlife, but also for broader scale connectivity. Monitoring of wildlife movement, distribution and abundance is time consuming and costly, and large gaps in knowledge for conservation planning remain. Local knowledge provides a means to help address these data gaps and limitations, while engaging local people and contributing to a more inclusive knowledge system. Accordingly, this study focuses on generating local tacit knowledge to help identify areas important to wildlife connectivity at a regional scale through an exploratory analysis using a participatory mapping approach. We focus on the local experiential knowledge of wildlife species, locations and movement pathways and landscape features that present opportunities or barriers to them. We address how such local knowledge enriches existing data and models, not simply through gap filling, but by offering a deep understanding of interrelating factors that influence wildlife patterns within the region. We explore means of spatially delineating 'fuzzy' boundaries, representing diverse perspectives and generating consensus in local knowledge. The mapped outputs may be used to supplement and validate formal-scientific data and models relevant to delineating areas for wildlife connectivity and adapting human infrastructural developments in the region. Through the process, we seek to enhance local participants' confidence in their knowledge and foster their support and future engagement in local conservation and other planning initiatives in the region, while contributing to more inclusive knowledge systems. We propose that the generation and engagement of local experiential knowledge can enhance understanding and support for wildlife connectivity planning. Our study provides broad intellectual contributions around validation or ground truthing modeling studies, where local knowledge provides a key tool for understanding knowledge about complex social-ecological systems that is increasingly coming from models that are unconnected to place and local people. As such, our approach and findings contribute to the scholarship and practice of connectivity conservation planning and PPGIS.

2.2 Materials and Methods

We used a mixed methods approach engaging qualitative and quantitative social and natural sciences to create a spatial data set of wildlife connectivity patterns across the region. A combination of participatory one-on-one mapping interviews and two focus-group mapping workshops elicited local, tacit knowledge. Individual participants' maps were digitized and

compiled into a computer-based mapping system. Spatial analyses were conducted to capture themes, similarities and differences among the compiled mapped data from the individual interviews and group workshops. Maps were prepared to overlay local knowledge maps with NCC's modeled wildlife habitat and movement pathways for discussion purposes. Explanatory texts from the participants' interviews and workshop discussions were used to enrich, support and interpret the participants' mapped data. The methodological details associated with each step are provided in the following sections.

2.2.1 Participatory mapping interviews

We conducted participatory mapping interviews (Brown et al., 2017; Brown et al., 2018b; Karimi & Brown, 2017; McCall, 2006) with local knowledge holders to gather textual and spatial data representing their knowledge of wildlife species, population locations, habitat and movement patterns in the Chignecto Isthmus. Recruitment purposefully targeted people with long-term, lived-experience on the land such as subsistence harvesters, woodlot owners, farmers, naturalists and recreational users of the land and wildlife. We conducted initial recruitment through local and provincial hunting and trapping, fishing and naturalist organizations, and in collaboration with NCC, who has preestablished relationships with individuals and organizations in the region. Supplemental 'chain-referral' or 'snowball' sampling (Biernacki & Waldorf, 1981; Sedgwick, 2013) was then employed, wherein interviewees were asked to suggest other potential participants knowledgeable of the land and wildlife. Recruitment ceased when no new referrals were forthcoming. Efforts were made to represent both provinces, aiming for 15-20 participants in each, and a breadth of experience and backgrounds. The participant sample was designed to reach the most knowledgeable local people while achieving a reasonable complement (n = 30–40) in terms of pragmatic logistical constraints such as time and funding, balanced against obtaining a range of viewpoints from knowledgeable individuals. The intent was to explore the deep experiential knowledge within this sub-section of the population, rather than be generalizable to the broader public. Preliminary screening ensured participants were knowledgeable of the region, identifying the nature of their relationship to the land and the time they had spent there. For the purpose of our study, "the local knowledge of an individual is unrelated to any institutional affiliation, and is the product of both the individual's cultural background and of a lifetime of interaction with his or her surroundings" (Loftus & Anthony, 2018,p. 158). Knowledge sought from participants was to be based on the livelihoods and pastimes of the individuals and gained through "extensive

observation" (Huntington, 2000) of the land and wildlife across the region over time. While it not possible to separate an individual's tacit knowledge gained through their time spent on the land from their training within organizations and institutions, we asked participants to share their personal and experiential views and information, rather than represent the perspectives or provide formal data gleaned from their employers or member organizations.

A total of 34 local people with tacit knowledge of wildlife in the region participated in one-on-one participatory mapping interviews. Often participants did not identify as one specific type of knowledge holder, but rather had experience through a variety of work and recreational activities. Participants were engaged in hunting and trapping for sport, sustenance and income; farming and agriculture; forestry both at industrial and private woodlot scales; wildlife rehabilitation and photography; as naturalists and trail groomers; and in other recreational uses such as fishing, canoeing, hiking, birding, snowmobiling, biking and cross-country skiing. Many participants have spent their lifetimes growing up and working in different capacities in the Chignecto Isthmus, with 11 participants from NS, 18 from NB and five who had lived on both sides of the border. While some participants are not originally from the region, their connection to the land is strong through their work and long-term residence in the area. The shortest time a participant has lived in the region is 10 years, with a large part of that involved being out on the land. We did not seek other demographic data from our participants as we did not intend to stratify our sample into sub-groups. Since we intentionally targeted recruitment toward people with longer histories of time and relevant experience in the region, participants tended to be ~40 years and older. Due to their long-term, deep engagement and familiarity with the region, we were able to collect a wide temporal range of data based on their knowledge, from the past to the present. Though we made significant efforts to increase recruitment of younger adults, women and Mi'kmaw individuals, these were largely unsuccessful, with only five women and none who identified as Indigenous participating in interviews. Particularly, we recognize that the inclusion of Mi'kmaw individuals is important, as the Chignecto Isthmus is situated within Mi'kma'ki, their ancestral and unceded territory. Unfortunately, the time frame of the study was insufficient to develop the relationships of trust and Indigenous methodologies necessary to meaningfully engage Mi'kmaw individuals in culturally appropriate ways. Inclusion of the Mi'Kmaq in dialogues and decision-making within their territory is important, as are the insights likely to emerge and as such their engagement in co-production of knowledge should be sought in future efforts (see Section 2.4.2).

We conducted semi-structured, face-to-face interviews in June-August 2019 in both NS and NB, at locations convenient for participants, such as at their farm, hunting cabin, or a central coffee shop in a nearby town. Interviews of 1-2 hour duration explored how participants view and value wildlife and wildlife habitat within the region. Interview-guide topics centred around several key questions used as prompts as they arose in natural conversations (Appendix A). Questions were not necessarily all asked or addressed in any specific order as interviews were conversational and participant driven, based on their own experiential knowledge of the region. The first portion of the interview established context and built rapport to learn more about where participants live, how they came to live in the area, where they have spent their time in the region and the activities through which they have experienced the land. The second portion focused on core topics involving wildlife species, population distributions, movement patterns, habitat, conservation, roadkill hotspots, threats and mitigation.

We solicited spatial data during the interviews through a participatory mapping component. Participants selected base maps from among five options at three scales (1:30 000, 1:60 000, 1:170 000) upon which to convey their knowledge of the region. The base maps were centred around the NS-NB border and showed major highways and secondary roads, towns, protected and conserved areas, lakes and rivers, forest cover and elevation contours, all sourced from 1:50 000 Topographic Data of Canada (CanVec Series, 2017). Land cover was classified simply as forest or non-forest where the forest cover layer comprises a single land cover category which does not classify dominant species or forest type (CanVec Series, 2017). Often, forest cover served to orient participants to specific areas in the region such as the location of a pipeline right-of-way (i.e. a distinct linear feature of non-forest) and frequent occurrences of wildlife road crossings (i.e. adjacent known patches of forest cover on both sides of a highway). Elevation contours were often used to identify areas of higher elevation around Hall's Hill and Uniacke Hill associated with known movements of terrestrial wildlife. Elevation contours were also useful for participants to orient themselves within the two main watersheds in the region and to identify two distinctive ridgelines in the region that were used as landmarks for recording wildlife observations. After the first few interviews, significant local landmarks emerged as identified by participants and were often used as points of reference for orienting and locating spatial data; these landmarks were added to the base maps. Key landmarks include the Old Ship Railway—a historical ship-railway route which is now used as a multi-use trail connecting the Bay of Fundy to the Northumberland Strait running from Tidnish to Fort Lawrence—and the

Canadian Broadcasting Corporation (CBC) radio towers located in the Tantramar Marsh near Sackville, NB, which were distinctive landmarks at the border region for decades but have since been demolished.

Participants chose the map(s) on which they felt most comfortable identifying their key areas and observations, with the option to use multiple maps at various scales. Paper maps provide an integral elicitation and engagement tool and a means of physically recording participants' responses in a spatial way. Participants were encouraged to draw directly on the maps, indicating any insights and tacit knowledge pertaining to wildlife, such as wildlife presence, absence and movements, particularly around roads, areas of concern for conservation, features that represent barriers to or heightened opportunities for wildlife movement, key areas used for their livelihood or recreational activities and their perception or the spatial extent of the Chignecto Isthmus as a region.

Individually-mapped data were scanned and georeferenced to align with base map coordinates within a Geographical Information System (ArcGIS). The maps were then digitized to identify specific species' presence, movement pathways and barriers to movement using layers of points, polylines and polygons. The individual maps were compiled and organized to form a thematic series of maps representing participants' landscape-based and experience-based knowledge of wildlife presence and pathways in the region. These were combined and overlaid to form group-consolidated thematic maps providing a composite landscape-scale perspective of wildlife presence and pathways in the region. Following the proposed methods outlined by McCall (2006) for representing local spatial knowledge through dynamic mapping, composite areas were shown as multi-layered zones with fuzzy boundaries in recognition that individually-delineated boundaries were not identical to each other. Local spatial knowledge often includes descriptive spatial terms and fuzzy boundaries which are not always perceived by participants as the same place or as existing in isolation (McCall, 2006). There are also multiple levels of detail that are not single occurrences of location but rather represent temporal and spatial ranges, such as those used for hunting and trapping, and seasonal wildlife usage. The need for precision in participatory GIS can change in accordance with the intended output and goals of the research. As outlined by McCall (2006), there is a need for less precision and lower resolution to represent various levels of certainty and confidence in the data. Such flexibility is appropriate in PPGIS applications aimed at eliciting and transferring generational knowledge for analysis of

conflict or consensus and management applications (McCall, 2006), such as in the case of our study.

2.2.2 Participatory mapping workshops

Subsequent to the individual map interview phase of our research, we held two sequential, half-day mapping workshops near the border in Aulac, NB, in January and February 2020. The aim was to review and refine the map series derived from the interviews. We invited a subset of 20 individuals from among the 34 interview participants, selected on the basis of their demonstrated, strong experiential knowledge of the land and wildlife in the region and high regard as such by those in the larger group. Eight of these individuals participated in the first workshop, in which we sought to verify the consistency and accuracy of our interpretations and compilations of the individual data. Spatial data were presented and discussed as a series of thematic consolidated maps of wildlife habitat, movement pathways and associated threats and barriers. The second workshop brought together the same group of participants with an additional two who were unavailable for the first workshop but were identified by others as important to include. Workshop participants continued to represent a mix of diverse roles and knowledge of the region including hunters and trappers, farmers, loggers, birders, wildlife rehabilitation workers, wildlife photographers, active members of the Chignecto Naturalist Club and conservationists. This active engagement across various livelihoods and lifeways provided the opportunity for a mix of diverse perspectives and expertise and allowed for strong consensus building across experiential domains to develop a robust data set of spatially mapped local, tacit knowledge.

Workshop participants were asked to comment on the consolidated maps and whether or not they thought they accurately and/or completely represented their knowledge of (i) areas of wildlife presence, habitat and movement pathways and (ii) areas that represent heightened opportunities or barriers to wildlife passage, such as landscape features or changes. They were encouraged to note areas of similarities and differences in the maps and factors such as level of confidence, agreement/consensus and rationale. The workshop facilitated the pooling of participants' knowledge and collective markings directly on the maps through roundtable map breakout groups, where refinements were noted, such as additional or missing data and spatial revisions. Large printed maps were provided of the compiled, thematic spatial data. Participants were broken into two smaller groups to assess each map sequentially and provide opportunity

to comment and draw on the maps, working through any areas of disagreement or uncertainty. Open focus-group discussions at the start and end of each workshop facilitated the sharing of participant's views, thoughts and opinions on the mapped data, expanding upon conversations and topics that had emerged.

After consensus was reached at workshop 1 on refinements to the initial consolidated thematic maps, the maps were updated to reflect the received inputs. In preparation for workshop 2, the outputs from NCC's wildlife movement pathway model (Nussey & Noseworthy, 2018) were also overlaid with the local knowledge holders' consensus maps to develop a new series of thematic maps. Maps of wildlife roadkill hotspots identified by Barnes et al. (2020; Barnes, 2019) were also presented for comparison. The resultant composite maps reflected themes based on species distribution, movement patterns and wildlife-road interactions derived from both local-tacit knowledge and formal-science models, privileging neither.

In the second participatory mapping workshop held with the same subset of participants, the composite maps were reviewed for accuracy and completeness and to explore whether and why there may be similarities and differences in the results derived from their knowledge and those generated from the two formal-science data sources: (i) NCC's model outputs of high-probability wildlife movement pathways derived from habitat-suitability and least-cost-path analyses for the 15 local species; and, (ii) roadkill hotspots statistically derived from roadside survey data in the region (Barnes, 2019; Barnes et al., 2020). Any differences between their tacit representations and the models were identified and discussed. Discussions also provided an opportunity to identify missing information in regard to other areas of habitat, wildlife movement or pathways and roadkill evidence. Questions explored whether they perceived problems with the model outputs; whether we had interpreted their feedback correctly or if further refinement was required in the maps; and why there may be differences between the model outputs and among their own knowledges of the land and wildlife. We also queried the most important patterns revealed through the maps, such as critical areas for supporting wildlife species and for addressing key threats to wildlife, and asked which species, if any, warrant heightened conservation attention.

After the second workshop, maps were refined based on participant feedback to create a series of final, local-consensus maps. Participants' input and remaining similarities and differences between local-consensus- and formal-science-derived maps were thematically and

spatially analyzed. Points raised by the participants during the second workshop were used to understand patterns which emerged in the local data and how they compared to the modelled data.

2.3 Results

2.3.1 Predominant species and threats

During the interviews, participants were first encouraged to speak freely about their knowledge of wildlife and wildlife movement in the region and were later asked about the species considered in NCC's modeling (see footnote 4). Species that featured prominently were closely tied to the livelihoods or relationships participants held with the land. These were predominantly large mammals, including moose, white-tailed deer and black bear and other furbearing species that were hunted and trapped, including beaver, otter, mink, muskrat, coyote, hare and fisher. Others were porcupine, various bird species, including waterfowl, songbirds and birds of prey, along with fish, primarily gaspereau. Often these lesser-mentioned species were talked about more generally across the expanse of the region or as species affected by barriers, such as roads, but were not considered of conservation concern. A common theme was the general decline in species abundance across the region over the past few decades. As noted by a local forest ecologist, biologist and birder, "essentially every animal that belongs in this ecosystem is still there, although in depleted numbers, from predators to songbirds" (P27)[5,6.]

Of the species modelled by the NCC, participants elaborated only on four, namely moose, black bear, hare and fisher, and showed considerable knowledge of habitat, movement pathways and barriers for black bear and moose (Figure 3a,b). Bears were said to be numerous and increases in bear activity across the region were noted, especially in NS, and often associated with forestry practices and agriculture, both of which were considered to provide enhanced food sources for bear. While key areas of habitat and points of observation were mapped for bear (Figure 3a), the common response was that you could find black bear

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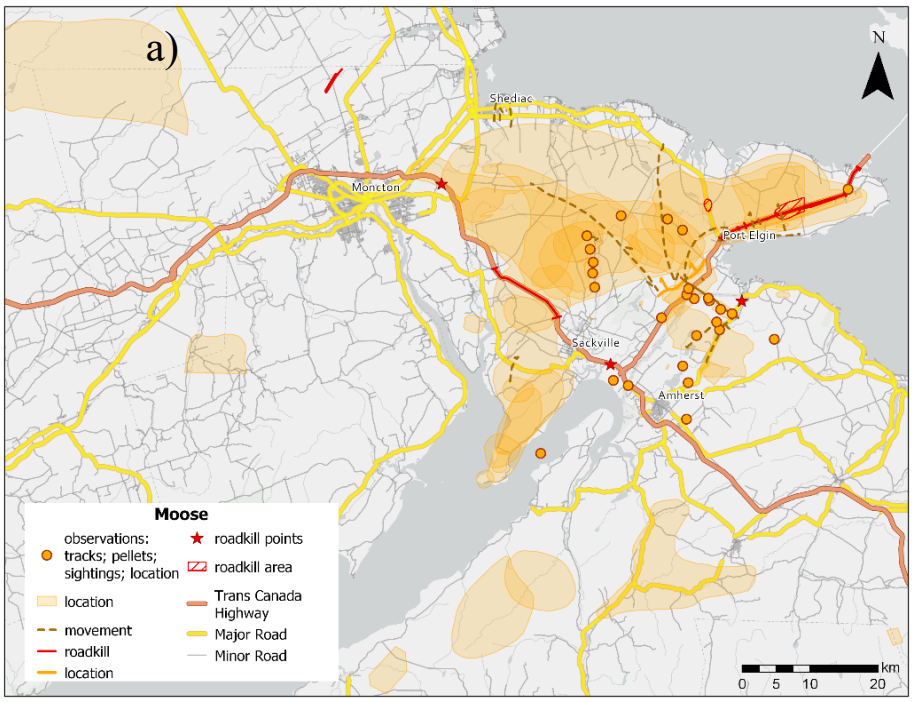
5 We assume that 'essentially' means 'almost', in this case, since wolf, eastern cougar, woodland caribou and others historically present have been extirpated over the past few centuries since Euro-American settlement.

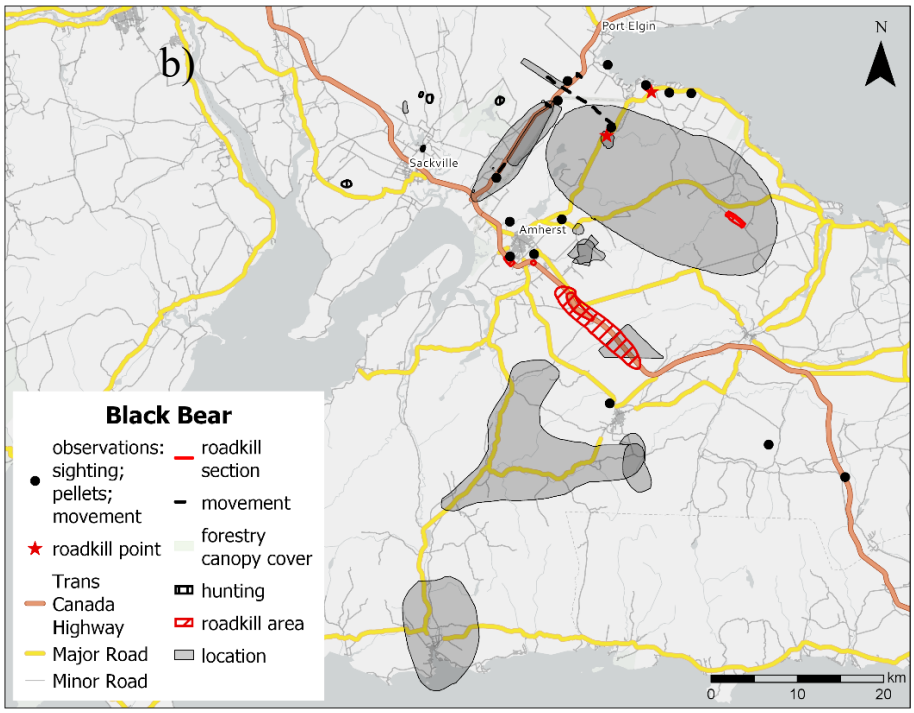
6 Participant numbers (e.g., P27, P22) are used to anonymise individual participant identity consistent with our approved research ethics procedure for attributing paraphrases and quotes to those who have conferred ideas, trends and information in reporting results.

'everywhere' and that the population was increasing: "years ago there was hardly a bear around, but now they're everywhere" (P25); and, "I mean, there's bears everywhere. More than people realize" (P15).

Moose were mapped very differently from bears by participants (Figure 3b). They noted many factors impacting the locations and movements of moose across the region, including competing deer populations and the associated brain worm, climate change, heavy tick loads, poaching and habitat fragmentation, consistent with published explanations (*P. tenuis* is a parasitic brain worm that deer can live with but is fatal to moose; for a summary, see Beazley et al., 2006). Many participants commented on the abundance of moose in NB and the dwindling population that persists in NS, with limited explanations as to why moose are not as abundant there. An avid hunter, trapper and past wildlife technician noted that moose "wander from the New Brunswick side, there's no doubt about it, but they don't seem to wander very far. Once they hit the Cobequid, along here, they just don't seem to migrate much further than that" (P22). Participants recognized that there appears to be abundant moose habitat within Nova Scotia, but did not know why moose do not prefer that habitat, stating "I can't really draw a conclusion if they will [move into Nova Scotia], because if they're not using it today, what's going to make them use it tomorrow" (P18), and "I often go into areas and scratch my head, 'why aren't there moose here?' The feed is there. The water is there. Everything is there for a moose, but there's no moose in the area" (P10).

Figure 3. Observed and known locations, movement pathways and roadkill areas for (a) black bear and (b) moose collected and compiled from individual participatory mapping data collected in July and August 2019. Road data collected from Government of Nova Scotia Geographic Data Directory (2020) and GeoNB Open Data Licence catalogue (2020).





There was speculation among participants as to why moose do not seem to persist in Nova Scotia yet remain abundant in New Brunswick. Poaching of moose in NS was raised as a concern by hunter, fisher and wildlife-technician participants (e.g., P1, 7, 18). Because native moose (*Alces alces* Americana) are officially listed as provincially endangered[7], it is illegal to hunt them in mainland Nova Scotia. Hunting for moose is allowed in the province of New Brunswick, with limiting regulations managed by a lottery draw for the ability to hunt them each season and a bag limit of one (Ministry of Natural Resources and Energy Development, 2020). However, illegal hunting was mentioned as a threat to moose moving into or on the Nova Scotia side of the border: "Yeah, all over this area, here, … poaching goes on, … as you get back in the woods. I played golf with this guy three years ago and he said, 'We poach one every year'!" (P7).

Another explanation that participants provided for relatively low numbers of moose in NS is increased temperatures impacting habitat selection, exacerbated by climate change. As a wildlife rehabilitation specialist noted, "they're [moose] starting to move further north, like up into the highlands, because of the temperature changes where there's enough variance that you can still get colder, snowier areas. The moose aren't going to like hotter areas" (P29). This same pattern was observed by hunters, trappers and lifetime farmers who commented on temperature being a large factor and noted that populations of moose tend to persist further north in NB where it is cooler. Although information specific to the study area is not available to substantiate temperature trends, regional temperatures in the Atlantic provinces are projected to increase by 3–4 °C over the next 80 years (Climate Change Nova Scotia, 2005); and, annual average temperatures in Nova Scotia have increased by 0.5°C over the past century (1895-1998) (Climate Change Nova Scotia, 2005). Due to latitudinal and ocean influences, temperature changes in the Atlantic region are projected to be relatively moderate; however, even small changes are considered likely to have negative effects on populations of species at the limits of their thermal tolerances, which may be the case with moose in the Chignecto region and the rest of mainland NS (Snaith et al., 2004; Beazley et al., 2006). Loss of mature forest cover adds to heat stress by limiting important opportunities for thermal regulation near forage in both summer and winter (Snaith et al, 2004; Beazley et al. 2006).

Some participants noted some relative changes in species abundance over many years, observed over generally extended temporal time frames spent on the land or hunting and trapping specific species. A common thread was consistency over time in the relatively high abundance of moose in NB as compared to NS. This trend remains evident in current

distributions of moose shown in Figure 3b, where there is a dense amount of moose related data recorded in NB versus smaller and more sparse pockets recorded in NS. This aligns with studies conducted in NS (Beazley et al., 2006; Nova Scotia Department of Natural Resources, 2007; Parker, 2003). In the early 2000s it was estimated that there were approximately 1000 moose left in mainland NS, however recent aerial surveys conducted by T. Millette for NS Lands and Forestry has revealed very low numbers of moose, underlying concerns that there are likely far fewer left in the wild than previously thought (McGregor, 2019).

Generally, when participants were asked to consider the 15 focal species that the NCC used to model their wildlife corridor, they were reported as present and well dispersed across the Isthmus. Red fox and deer were described as more likely to be found around towns where they were safer from predators and near food sources. Deer and bear were said to be abundant around foraging areas such as farmers' fields and deer wintering areas. In terms of relative declines and increases in abundances, deer and hare were frequently mentioned, noting a cyclical nature based on predatory pressures, hard winters, and food availability rather than a steady trend over the years.

As for the factors affecting species, several key themes arose from the interviews. Participants identified several barriers to wildlife movement across the Chignecto Isthmus, indicating that while roads provide an obvious physical detriment to movement, factors such as highway speed and forest cover are likely compounding limiting factors. A resounding factor, deeply expressed and agreed throughout, was the relatively fast rate at which the landscape has been changing over the past 30, 10 and as recently as 5 years. Landscape changes were considered to have not only impacted the resilience and abundance of species, but also their ability to move freely between NS and NB. Participants remarked on the proliferation of roads, especially for forestry, which have also facilitated access into natural areas. They described an increase in extent and intensity of forestry activities, which have diminished old growth forests and converted habitat through frequent clear cutting and herbicide applications. Noticeable increases in road speed, traffic and tourism-related travel were also reported.

Though anecdotal and relative, these qualitative observations are consistent with landscape changes reported in other studies. Human footprint (HF) scores in the Isthmus are higher than average distributions across the larger Acadian/Northern Appalachian ecoregion, with HF scores of 21-30 (out of 100) assigned to most of the Isthmus and higher HF scores (41-

60) in a broad swath dissecting the Isthmus; as such, the Chignecto Isthmus region is classified as 'high threat', defined as 'above average' levels for the ecoregion (Trombulak et al., 2008; Woolmer et al., 2008). In general, many wildlife species are negatively affected by roads (for overviews relevant to the study area, see Fudge et al. (2007) and Beazley et al. (2004)). Moose populations have been shown to be vulnerable to increased hunting pressure near roads, especially illegal hunting; and in NB, 92% of moose killed by hunters occurred within 1 km of forest roads (Boer, 1990). Densities for roads and trails across the study region are 'moderate' to 'very high' (Snaith et al., 2004; Beazley et al., 2004) and higher than a suggested threshold (0.6 km/km2) for sustaining mammal populations in naturally functioning landscapes (Forman et al., 1997). Once road influence zones are taken into account, remnant forest patches are small and fragmented (MacDonald & Clowater, 2005); average forest patch size across the region is < 5.0 hectares (Cunningham et al. 2020). Forestry practices, including clearcutting and herbicide spraying have been criticized in NS (see Lahey, 2018 for an in-depth, independent review). Local species declines and the need for attention to such threats are documented in status reports and recovery plans for species at risk, provincially (e.g., Parker 2003; NS DNR 2007) and nationally (e.g., COSEWIC 2018; ECCC 2016), and reflected in the region's designation as one of Canada's Community-Nominated Priority Places for Species at Risk (ECCC, 2019). Accordingly, there is strong agreement between the participants' observations and the small number of potentially corroborating studies available, with the local descriptions infusing rich explanatory insights to the local socio-ecological context.

2.3.2 Patterns in spatial elicitation through participatory mapping

Based on predominant spatial data emerging from the participatory interview mapping, eight thematic maps were produced: (i) avian species presence, movement and roadkill; (ii) movement pathways of terrestrial wildlife; (iii) point locations, sections and areas of roadkill for terrestrial species; (iv–vii) location, movement and roadkill for black bear, moose, deer and other fur-bearing species; and (viii) overlapping moose and deer locations, movement patterns and observations (see Figures 3-5). These maps served as the basis of discussion for workshop 1. At the workshop, participants indicated that the locations of species and other mapped spatial knowledge were reflective of what they had indicated in their individual interviews. Although there were instances where participants noted a gap, they later discovered that the data was included on a map other than the one they were examining at the moment. As a consequence, the participants neither added nor removed information and requested no refinements to the

consolidated, thematic maps, although encouraged to do so. Despite being mapped separately by 34 individuals, participants noted a high degree of agreement in their spatial representations. Accordingly, participants considered group consensus to have been established for the mapped information presented regarding species locations, movement pathways and roadkill areas for moose, deer and black bear and a suite of furbearing mammals. Participants in the two consecutive workshops reported that they were able to see their knowledge, along with the compilation of data from other participants, reflected in the maps, and that this increased their confidence in their knowledge in terms of its veracity and spatial accuracy.

That said, methods varied by which participants used base maps to record their knowledge. The spatial extent of their perceptions of the region, wildlife habitat, movement and barriers varied widely, drawing upon various map scales; 42 individual maps were produced at 1:30000 (n=11), 1:60000 (n=18) and 1:170000 (n=13). Some spoke broadly about general patterns and habitats across large geographical extents at a coarse level of detail, while others conveyed finely-detailed knowledge in local vicinities, recording a total of 556 discrete points, lines and polygons to record their knowledge of 47 different species. Their degrees of confidence varied across scales and background knowledge. Participants often demonstrated a desire to record a precise location, yet if they felt any uncertainty in spatial precision, they hesitated to place a mark on the map. In such cases, we encouraged them to make the mark according to their best judgment while representing uncertainty by a dashed line. Interestingly, when data were later compiled and collectively reviewed during the workshops, it was clear that there was much consensus in the various attributes that had been marked by individual participants, with uncertainty at the individual level overcome at the group level.

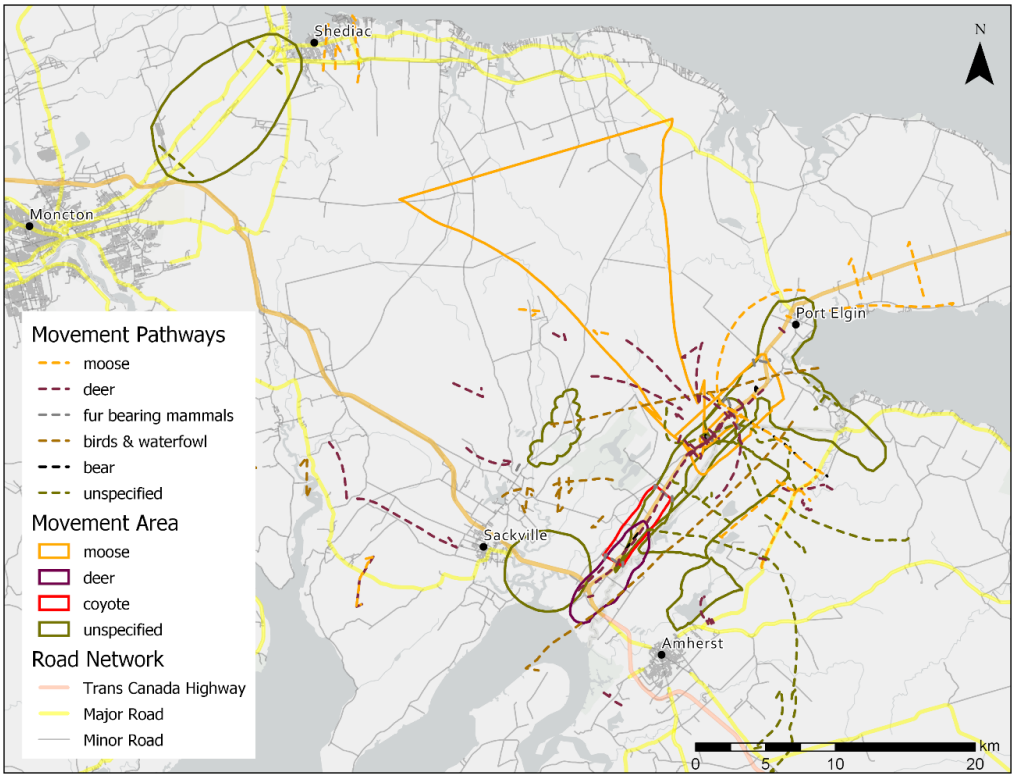
2.3.2.1 Wildlife movement pathways

A total of 129 discrete points, lines and polygons were drawn for 15 different species to indicate movement pathways (Figure 4) along with 41 records of roadkill sections (Figure 5) along key stretches of road, which also are indicative of wildlife movement within these areas. Pathways were merged in a single map layer to represent composite movements for all species (Figure 4). There were differences in ways individuals represented and thought about wildlife movement pathways. Some thought in terms of roads and how species were forced to move either across or along them. Their notations would often indicate an area or section of road where species frequently moved along (n=12) or across (n=34), at times representing places where species would readily cross due to factors such as higher elevation (n=16) (versus low-

lying wetlands and coastal marshes) or tree cover on either side of the road. At other times, these represented observations of wildlife crossing the road, wildlife tracks or high numbers of incidences of roadkill in the area. Of note was a 1-km road section along Highway 16 between Aulac and Port Elgin, NB, which is the sole area along that highway with remnant tree cover on both sides. Wildlife, both live and roadkill, were reported to be frequently seen in this location. The surrounding landscape has been cleared for agriculture, housing and forestry.

Many participants noted that wildlife often travelled along 'paths of least resistance'. The most frequently mentioned was a natural gas pipeline right of way, which runs North-West to South-East across the NS-NB border and Highway 16 near Hall's Hill, NB. The pipeline is cleared of brush along its entire route but remains forested on either side and is relatively less frequently bisected by fences and devoid of other human developments as compared with other potential routes. Several participants have observed wildlife and other evidence of travel along this corridor, such as moose and black bear sightings, tracks and scat. Similar use of human-made routes was noted for moose and black bear in areas where logging roads and other forestry activities have permeated forested regions. Participants often reported that wildlife may be seen travelling along logging roads as they move through an area, and often recorded observations of species sightings or signs (tracks and scat) along these routes when mapping out their spatial knowledge. Some participants reflected that there may be increased observations in these areas due to increased human presence facilitated by road or trail access, consistent with observational or sampling bias often reported in field studies. As one trapper, hunter and fisher said, "I'd see tracks all over where the cuts [clear cuts and logging roads] are. The only reason I would see them there is because those are the places where I have access, where I can get to" (P4).

Figure 4. Movement pathways recorded and compiled from individual participatory mapping interview (July and August 2019) identifying areas and pathways for terrestrial and avian species across the Chignecto Isthmus. Road data collected from Government of Nova Scotia Geographic Data Directory (2020) and GeoNB Open Data Licence catalogue (2020).



Others described wildlife movement in a broader context in terms of how species move throughout the region, particularly across the NS-NB border and between suitable areas of habitat for specific species (Figure 4). At this broader scale, it was also noted by several participants that the region between Halls Hill and Uniacke Hill along Hwy 16 is the highest point of elevation when crossing between the two provinces and provides a natural funnel where terrestrial wildlife are "streamlined" (P3) across the Isthmus. When describing how wildlife move between New Brunswick and Nova Scotia, some participants drew an hourglass shape which captured suitable habitat on either side of the border for terrestrial wildlife but was constricted through a pinch-point in the border region, along this area of higher elevation.

Temporal, daily and seasonal, movement pathways were also indicated, particularly for deer and migratory birds. Wintering areas and deer yards were often delineated, along with areas where deer would frequently graze in agricultural fields and near salt marshes, and spring and fall movement pathways in and out of wintering areas. These pathways often included areas

along and across roads where high frequencies of vehicle-deer collisions and deer crossings were reported. Temporal movements were also recorded for migratory birds such as the American Black Duck and Common Eider. In contrast to most patterns, migratory birds were shown as moving across the Isthmus from the Northumberland Strait to the Bay of Fundy (Figure 4). Human changes to the landscape were noted as interfering with these daily and migratory flightpaths, acting as barriers to movement. A couple of participants who are hunters and also work in the conservation field identified power lines that stretch across pastures near the High Marsh Road just west of the NS-NB border that birds would strike on their daily flight paths at dusk and dawn. The powerlines were described as so frequently deadly that eagles have begun to perch and wait there to scavenge dead, stunned or injured prey (P8, P9). The wind turbines located between Sackville NB and Amherst NS were also stressed as a deterrent to movement for bird species and associated fencing as a barrier to other species (P13).

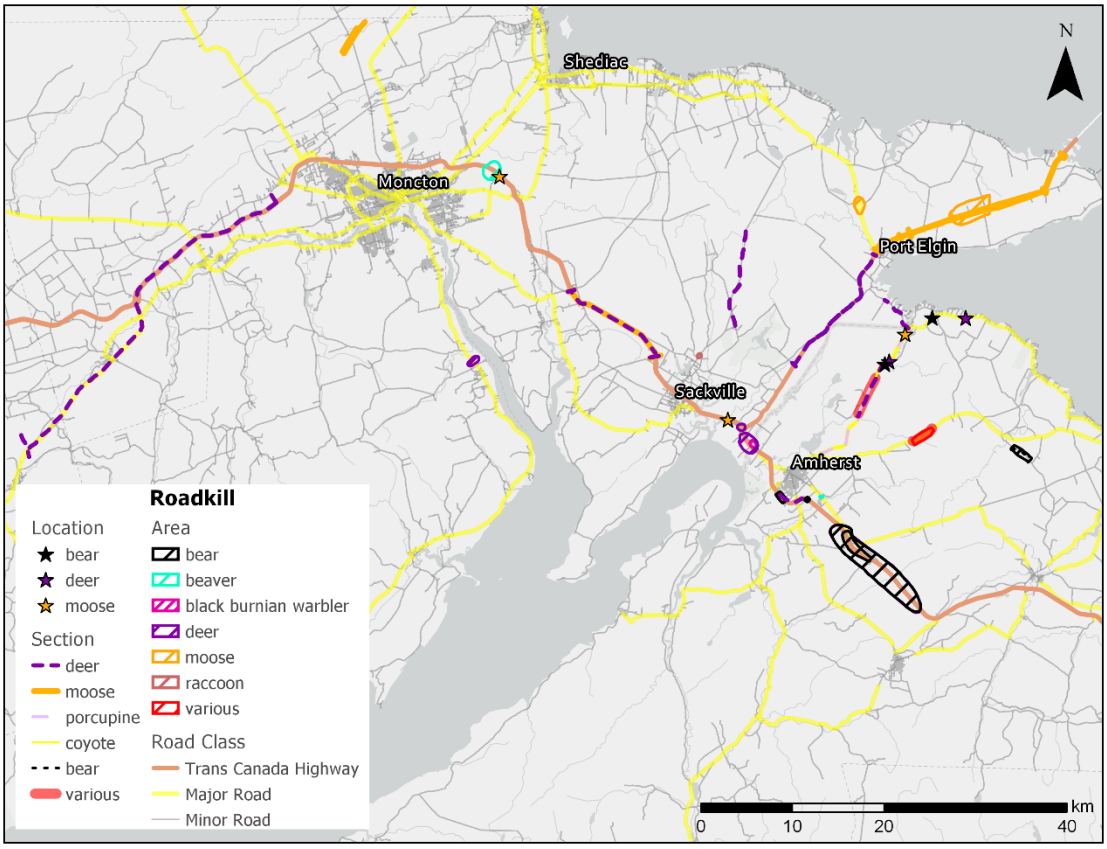
2.3.2.2 Threats to wildlife habitat and movement

Roadkill in general was frequently mapped during the interviews (Figure 5), primarily for deer, moose and black bear. Moose was noted as a hazard to drivers and most frequently hit in New Brunswick on Hwy 16 between Port Elgin and the bridge to Prince Edward Island. This stretch of Hwy 16 is notorious for vehicle-wildlife collisions and was highlighted 16 times as a hotspot for moose crossings and roadkill. Several participants indicated the surrounding area as moose habitat, supporting a healthy moose population (Figure 3b). Deer movements were also marked along the same highway, but south of the moose hotspot between Port Elgin and Halls Hill (Figure 5). Deer roadkill hotspots were also noted along the Tyndal road east of Hwy 16 in NS and at the Aulac, NB interchange at the start of Hwy 16. Black bear roadkill locations were noted along the Tyndal Road in NS; near cottages in Tidnish, NS along the Northumberland Shore; and along the Trans-Canada Highway east of Amherst. The hotspot on the Trans-Canada Highway separates two large black bear habitat areas and populations identified by participants (Figure 3a).

Increasing human-wildlife conflicts (Manfredo, 2008), especially pertaining to moose, can result in varying societal attitudes and values (Messmer, 2000). In NB where many rural routes and highways pass through moose habitat, there is the potential of increased risk of moose-vehicle collisions which could cause damage to vehicles or have the potential to injure and kill both wildlife and humans. Individual and social characteristics can influence one's risk

perception; the evaluation of the probability and consequences of an unwanted outcome or probability of one experiencing the effects of danger (Peters-Guarin, Mccall, & van Westen, 2012; Sjöberg, Moen, & Rundmo, 2004). Risk perception can be amplified by a mixture of individual, social, and environmental factors combined with perceptions and attitudes influenced by testimonials of extreme events (Manfredo et al., 2009). This may well be the case with the participants in our study. Collision data from the NB Department of Energy and Resource Development show 13 records of dead moose on NB routes 15 and 16 from 2013-2018 (Barnes, 2019), and in an eight-week period in May-June 2017, vehicle-moose collisions averaged one per week (Letterick, 2017). Related media and other attention may have fostered a heightened sensitivity to moose-road interactions among our participants, resulting in its prevalence in their reports; however, it is also the case that high rates of moose-vehicle incidents do occur in this area of NB.

Figure 5. Points, lines and polygons of recorded areas of roadkill for various species, compiled from individual participatory mapping interviews, July and August 2019. Road data collected from Government of Nova Scotia Geographic Data Directory (2020) and GeoNB Open Data Licence catalogue (2020).



Forestry was another predominant emerging theme that was often discussed and sometimes mapped during the interviews. Except for providing improved forage habitat for black bears, forestry was often discussed with a high level of frustration and concern for the 'devastation' it causes, resulting in a continuously changing landscape across the Chignecto Isthmus. Although some participants have worked in the industry and privately log wood from their land, there was overwhelming consensus that industrial silvicultural practices have rapidly shifted the landscape and negatively impacted habitat quality and quantity in the region.

> P10: We can go for a drive today and drive up in this area and see moose tracks, but does it represent or have any remnants of what it was like 35 or 40 years ago? Not even close, and it never will. That piece of ground will never be the same. Those things in itself, to me, are changes that are irreversible and are going to represent some sort of adversity to wildlife [referring to swaths of land currently being used for industrial forestry]

Referred to as "death by a thousand cuts" (P27), the impacts of forestry across the region have "devastated diverse ecology" (P27). What was once a mature, mixed Acadian forest is now younger plantations of jack pine and balsam fir, creating monocultures which have stripped away wintering areas for deer and feed for moose (P17, P18, P28). Participants criticized such practices, calling the push toward monoculture as 'borealization' due to the focus on specific softwood species, disrupting the balance in Acadian forests (P27, P28).

2.3.3 Comparison with modeled wildlife movement pathways and roadkill hotspots

Local, tacit knowledge maps were overlaid with NCC's high-probability wildlife movement pathways (Nussey &Noseworthy, 2018). This resulted in four additional maps being created and discussed at Workshop 2. Two maps overlaid participatory mapping for moose and bear with outputs from NCC's population patch, breeding patch and least-cost-path models for these species (Figure 5a,b). Two other maps overlaid NCC's modelled wildlife movement pathway with participatory mapping of roadkill, habitat, and species occurrence observations (Figure 6) and movement patterns for all species (Figure 7). Spatial similarities were evident when participants' mapped data were compared to NCC's modelled outputs for both moose and bear (Figure 5a,b). The existing protected areas used as 'patches' to be linked in NCC's pathway modelling were also identified by participants as habitat areas for several species, including moose and bear. NCC's modeled suitable habitat and breeding patches[i] were also similar to

areas captured by participants' location, habitat and movement pathway data. A population patch is the minimum area which can sustain a breeding pair for ten years and a breeding patch is the minimum area needed for a breeding pair (Beier, 2006). Nonetheless, the participants also noted other wildlife movement patterns lying outside of the high-probability movement pathway and other areas for species that were not modelled by NCC.

Participants had identified three major hotspots of roadkill across the NS-NB border that also fall within the NCC's modelled high-probability wildlife movement pathway (Figure 7). These three major roadkill hotspots were along Hwys 940 and 16 for deer and the Tyndal Road (Hwy 366) for deer, porcupine, bear and coyote. These three major roads run parallel to each other and transect areas identified by both participants and the modelled data as an area with an abundance of wildlife movement and habitat location. Deer presence and abundance was noted to be concentrated along the NS-NB border in the agricultural belt along Hwy 16 between Point de Bute and Baie Verte as well as in another pocket East of Hwy 940. Deer movement was reported as heavy between habitat patches alongside Hwy 16, with increased roadkill occurring during spring movements from wintering areas. Roadkill hotspots identified through roadside field surveys conducted in the region in 2018 (Barnes 2019; Barnes et al. 2020) revealed overlap with road sections that intersect with NCC's modelled high-probability wildlife movement pathway. Some of these overlapping areas are also consistent with movement and roadkill observations indicated by participants including areas highlighted along Hwy 366 and Hwy 16 (Figure 7). Most of the species movements mapped by participants converge into a major pinch-point across the border, as in NCC's model (Figure 8). There was group consensus that their compiled spatial data bore strong similarities to the modelled outputs, with no outliers or glaring differences to address between the two sources of information. NCC's modelled pathways aimed to optimize landscape conditions and minimize movement costs for the suite of species considered, including bear and moose, which participants also mapped. The similarity in patterns seems to suggest that the participants and the modellers have consistent understandings of the conditions favourable to these species and where they occur on the landscape. It likely also reflects the somewhat limited options for wildlife in making their way through the region.

The conversation transitioned to possible factors as to why the observed trends were occurring, particularly pertaining to the types of landscape changes impacting wildlife. Once again, forestry impacts dominated the conversation (i.e., excessive clearcutting, use of

herbicides and logging roads). Participants reported increasing human access into once remote spaces through the development of access roads without restrictions on recreational users. Concerns were also raised about increased highway and road traffic in general, which they attributed in part to increased tourism. Little regard for speed limits by many drivers on some of the highways was noted, with participants recommending better outreach and mitigation in terms of signage to raise awareness of high vehicle-wildlife collision risk. Overall, landscape changes were considered the major driver of wildlife locations and movement patterns, most often as direct limiting factors and barriers, but also including indirect effects such as related to increased disease and ticks.

Figure 6. NCC modelled connectivity data (Nussey & Noseworthy, 2018) overlaid with participatory GIS data for (a) black bear and (b) moose.

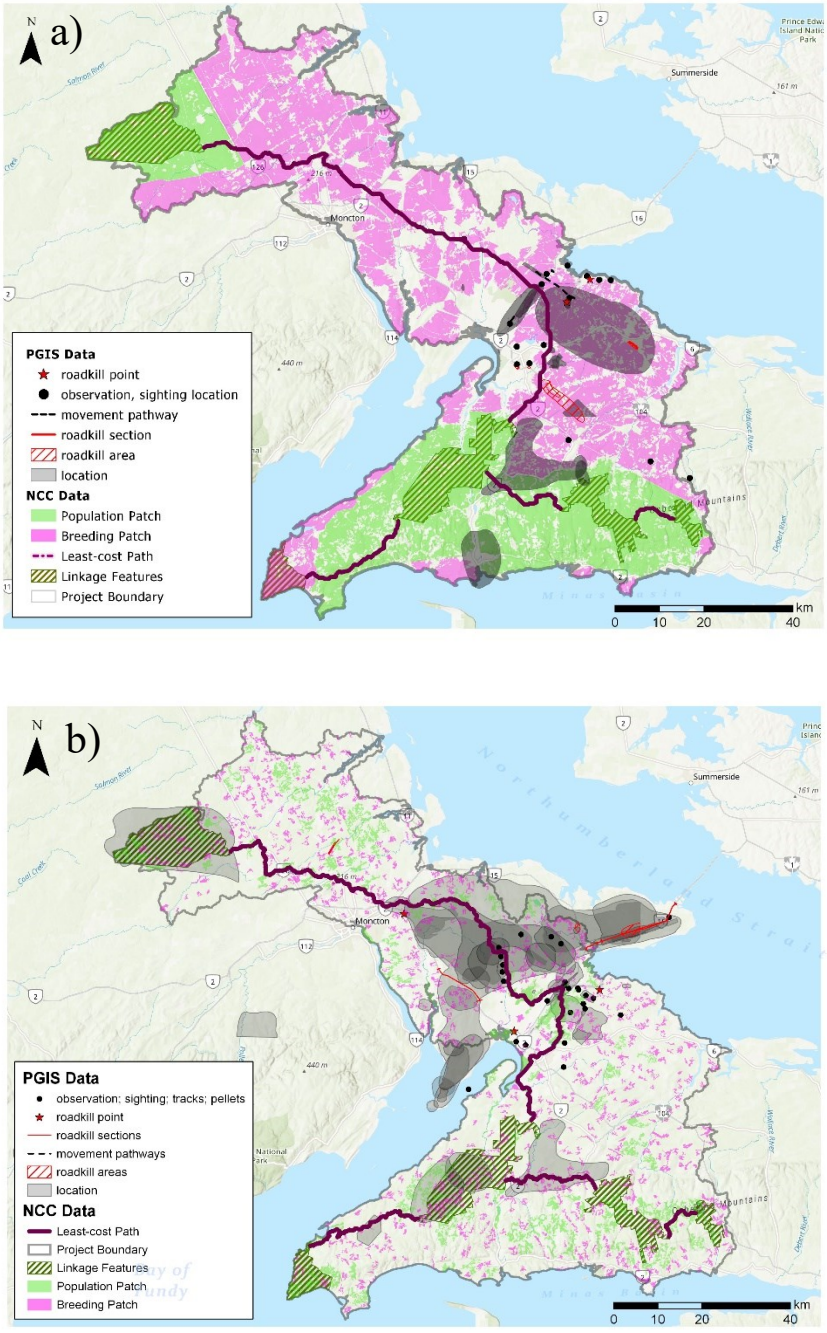


Figure 7. Species location and roadkill data for all species mapped and compiled from individual interviews (July and August 2019) overlaid with NCC's modelled high-probability wildlife movement pathway. Inset A highlights the 5-km wide pinch point along the NS-NB border identified in the NCC report (Nussey & Noseworthy, 2018).

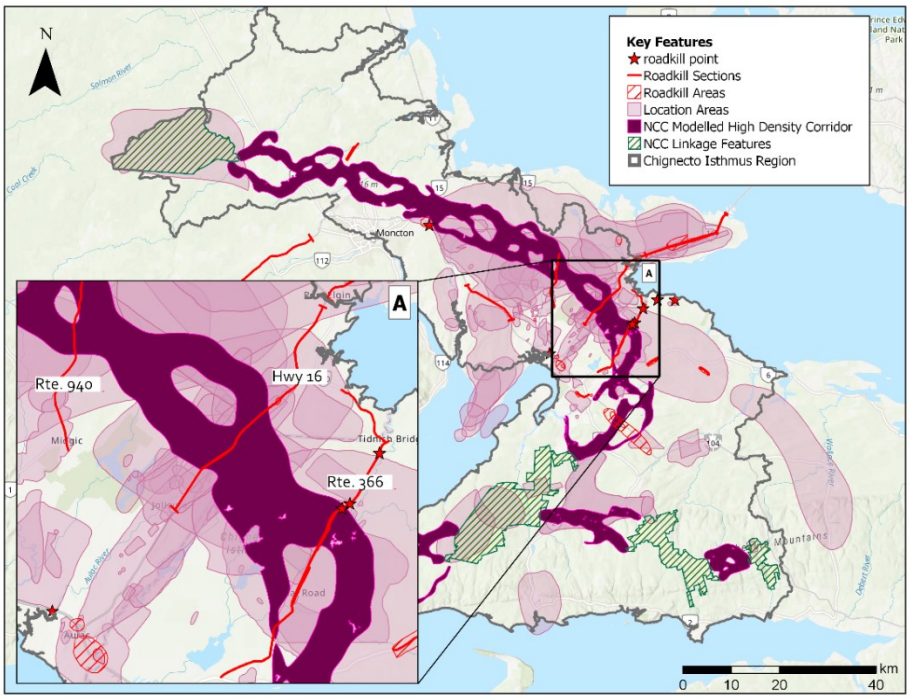
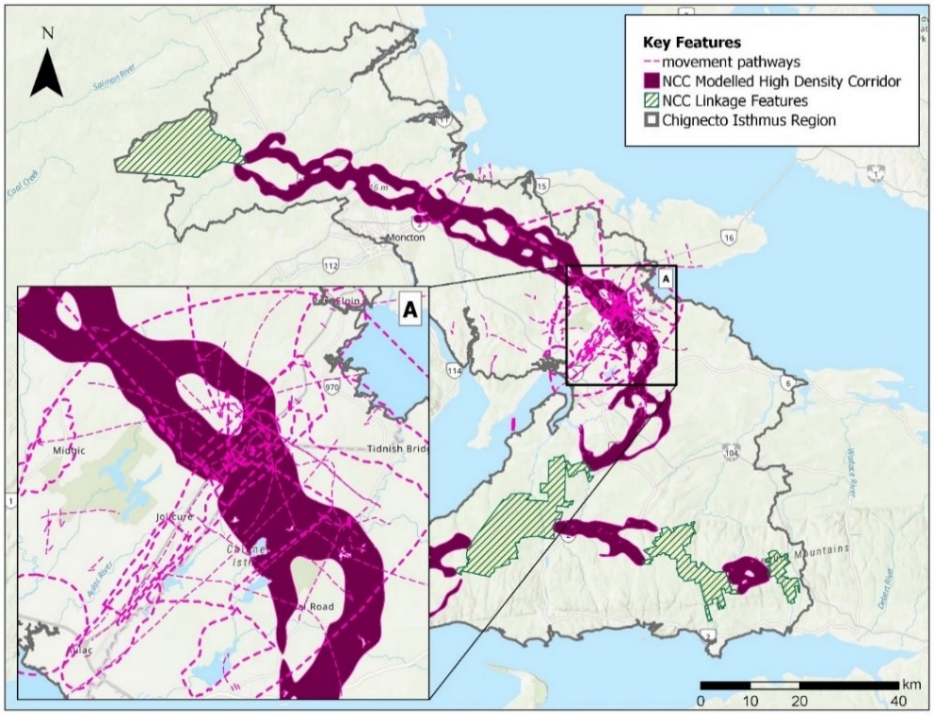


Figure 8. Movement pathway data for all species mapped and compiled from individual interviews (July and August 2019) overlaid with NCC's modelled high-probability wildlife movement pathway. Inset A highlights the 5-km wide pinchpoint along the NS-NB border identified by participants and in the NCC report (Nussey & Noseworthy, 2018).



2.3.4 Emergent themes

2.3.4.1 Species of conservation concern

Participants agreed that moose are of conservation concern in NS, though plentiful in NB, and bear are increasing everywhere. They were relatively silent on other species, though concerned about general declines. Less clear, though a recurrent theme in conversations, was the question of whether deer are a nuisance or a species of conservation importance. A total of 126 points, lines and polygons were mapped during individual interviews to indicate habitat, locations, movement and roadkill for deer. While some viewed deer as pests who yard in their pastures and feed off their crops, in some cases these same participants also talked about deer in a positive light, indicating a complex relationship. Others simply enjoyed the sight of deer on their property and the opportunity to photograph them. Regardless, deer were talked about widely across all participants, who perceived the species as having the potential to shed light on key landscape changes and habitat fragmentation in the area. As noted by a local wildlife biologist, "…not that deer are endangered. That is not to say they're not important [….] It [deer]

became a symbol of the corridor and the deer told that story. I don't know if you'd call it a keystone species, […] but I think it's a good indicator of why that corridor is important" (P15).

Participants also spoke to interactions between deer and moose, recognizing them as 'competing' species, and further, that they cannot inhabit the same space due to the detrimental impacts of a 'brain worm' on moose, which is a parasite (P. tenuis) carried by deer but deadly to moose (for a description, see Beazley et al., 2006). They acknowledged that deer and moose have different habitat requirements and that landscape changes from agriculture, forestry, roads and other activities have favoured deer and caused incursions into or overlaps with moose territory. At the same time, however, several noted that forestry activities also negatively impact deer, such as by interrupting their ability to move through areas or find suitable habitat and feed. As such, many saw deer as an indicator of the severity of the adverse impacts of landscape change and current forestry management practices for other, more sensitive species (P2, P4, P10, P20). These perceptions are consistent with those reported for these species more generally in Nova Scotia and elsewhere (see, for example, Snaith & Beazley, 2004b; Snaith et al., 2004; Beazley et al., 2006; Parker, 2003; Lahey, 2018).

2.3.4.2 Species and ecological interrelationships

References to 'totality' and interconnections were prevalent among participants, who acknowledged that ecological systems are intricate and complex, and therefore you cannot focus on one component alone. For example, "So, in terms of the Isthmus—in terms of the ecological things you can think about—it is so important, eh? … [J]ust the … different species, and so on" (P3); and,

> P27: [I]f you get anybody out and then try to have a connection—let them have a connection and see that—what connects to what, like that salamander connects to that—it doesn't matter how big a snake, … anything. It all starts down here. You know, moss and the grass and then, you know, like, you gotta look at the whole picture.

Participants recognized that wildlife, resource management systems and social interactions do not act independently and are intricately connected in the landscape. Such observations are reflective of systems thinking (Davis & Stroink, 2016) and social-ecological systems frameworks (Kittinger et al., 2013; Ostrom, 2009), in which humans are intertwined with their environment. They situate the wildlife patterns within the complex social-ecological systems of the region, enriching existing data and models. During an interview, one participant,

a wildlife rehabilitation technician, remarked, "[F]ew biologists will sit down and look at these issues in their totality, […] and that's what a project like this can do, is bring some clarity to those kinds of issues" (P29). Recognizing what the project can do—situating formal data within broader local tacit knowledges to bring context, clarity and utility to decision-making—is consistent with social-ecological-systems thinking, as is its representation through participatory mapping (Karimi et al., 2015). The value of the larger story and inclusive knowledge mobilization was acknowledged by participants, such as in stating that "the problem is we have a lot of environmental groups and activists out there that don't know what the story is…. So, what you're doing is telling the story" (P29).

Participants are not naïve about the social-ecological complexities of the situation, however, and noted challenges associated with the geographical extent of the Chignecto Isthmus, recognizing it encompasses multiple jurisdictions. Not only do ecosystems vary across the region, but so do institutional mandates, policies and social relations, creating problems for conservation governance, as pointed out by (Wyborn & Bixler, 2013). The scale of the challenge, especially when considering the role of human values and pragmatic factors inherent to decision making, is recognized by participants:

> P29: I mean, it's a massive undertaking. It's so complex and distanced from the realities in nature. The arguments, like, should we stop spraying the forests to protect the deer, when in both instances they're both invasive issues? […] We're no longer making choices of environmental stability; we're making choices of preferences over things that will make it.

Adding to the complexity and urgency of the situation are uncertainties and measures needed to adapt to sea-level rise in this mostly low-lying, coastal region, both for wildlife and human infrastructure.

2.3.4.3 Sea-level rise

At the outset, our study assumed sea-level rise as a 'given', rather than as a research question. Accordingly, we did not ask participants specifically about the effects of sea-level rise. Regardless, several participants spoke about 'water' levels being an impediment to wildlife movements due to the large extent of wetlands and marshes and many streams and undulating coastline in the area. At least one participant fully recognized the effects of climate change and

sea level rise on movement pathways, associating it with the funneling effect on wildlife movement visible in Fig. 4.

> P27: And it's also the highest point of land on this size of the Isthmus. This is 350-foot elevation, and that's kind of important for looking at climate change and, you know, sea-level increases. Because, essentially, that elevation works like this: the elevations go from here, up through the top of this area here, which is the ridge—Jolicure. So, this is the highway, and this is all, of course, relatively low, compared to sea level, here. So that kind of constitutes an important movement area, especially with the climate change stuff happening.

The ridge of higher elevation traversing the Isthmus was recognized as an important movement pathway for animals; participants recognized it as a safe passageway for animals who could not make their way through boggy or wet areas. Although not all participants linked it to sea-level rise, some went on to elaborate that part of the change on the Isthmus was associated with water levels and that these water levels affected not only human activity but also influenced animal movements and wildlife populations (influencing decline of some species while others became 'overpopulated'). The importance of the higher elevation area for movements was linked with seasonal effects on wet areas at lower elevations.

Observations associated most wildlife movements with the higher ridge of elevation, while recognizing that wetter areas are used in the winter when the water and land is frozen, facilitating traverse over firmer terrain: "… [T]here's seasonal travel through this wet area, …. Yeah, that would be of concern to some species. And once you get up to here [inland], I know there's a rise in elevation, there's more forest" (P12). Terrestrial ungulates (i.e. deer and moose) were reported to move through water on occasion but only in areas with adjacent habitat for landing and shelter. Participants widely noted the negative influences of forestry practices on cover habitat and associated this loss of habitat with influencing movement not only in the obvious ways (e.g. cutting out that forest, fragmenting landscape etc.) but also by no longer providing landing sites for possible movements through water, which may be further exacerbated by rising water levels in the region.

> P12: There's definitely a seasonal component, actually, to the animal movement through here, in my opinion. I hear—people would tell me stories when I was doing the wind farm

bird surveys, they were telling me that—this is a long time ago, probably in the 1960s—they had this moose going out to the, to the water and swimming over here to this peninsula. And they, they saw it.... But I don't think it's happening today.

Other participants also recognized that changing water levels, particularly deeper levels, pose movement challenges for particular species (i.e. deer, bear, coyote, small mammals). Deeper water is recognized as a direct barrier to movement: "They [deer] could cross over [but] it's pretty deep water so they're not likely going across here because of that barrier" (P8). Some observed increases in siltation and how this has influenced water levels in the region, especially pertaining to rivers and the Bay of Fundy. Participants noted fish populations and movements as being affected by receding waterlines and muddied shorelines. Impediments to deer movements along shorelines of rivers to cool off and to access food and water were also noted as of concern, with muddied shorelines affecting their ability to walk.

P1: Into the Bay of Fundy. This is a tremendous change here, over the last 4 or 5 years.... I go down there every year .... [W]e used to walk the shore. Can't walk the shore anymore. There's a tremendous influx of silt, here, and the only open water now is over by the fields on this side.... On this side, this is all silted in. There's a tremendous amount of silt here, and that's 4, 5 years.... We suspect—my friend and I—that it's come down the Petitcodiac River after they opened the causeway. Yeah, and there was a lot of silt accumulated there.... [T]here's a tremendous, tremendous change there. That's probably going to be good for the shorebirds but it's just muck. You can't walk. It [deer] would be a fool to walk on it. But, uh, it's changed tremendously.

One participant spoke directly to the tenuous circumstance provided by the prevalence of water, recognizing the importance of the land bridge and associated infrastructure such as dykes to maintain terrestrial connections through the Isthmus, for both social and ecological reasons.

P5: Yeah, without it, Nova Scotia would become an island.... [T]here are big parts of the Isthmus that are protected by dykes; and, uh, if the dykes fail or the dykes are breached, Nova Scotia will very quickly run out of what they consume and buy in the store. The railway, the rail line, is right across the Isthmus, and all the roads go across the Isthmus .... So, the only connection NS would have to the rest of us in the case of breached dykes

would be by air! But also, there's some very interesting wetlands up through the Isthmus. The Chignecto, … the Missaguash River, and all the complex of lakes and so on. The Isthmus is—it's an interesting canoe ride, to go from … Point de Bute… to Hall's Hill.

Observations like this recognize that sea-level rise presents an important current and future context for wildlife in the region. They are consistent with studies showing that sea levels are rising, storm surges and flood events are increasing, and the land is subsiding due to post glaciation isostatic rebound (Greenberg et al., 2012; Shaw et al., 1998; Shaw et al., 2010; Webster et al., 2012). As such, the already narrow land connection between NS and the remainder of North America region is predicted to be much narrower, and in instances of storm surges potentially severed completely, as has occurred at times in the past. Although our intention was not to address this issue explicitly, participants raised it nonetheless. It supports the rationale for generating local insights on current wildlife populations, locations and movement pathways within the context of larger social-ecological contexts, to provide more inclusive knowledge systems as baseline data for various conservation and other planning responses to sea-level rise in the region.

2.4 Discussion

Knowledge creation such as in this study is important for conservation planning, particularly for connectivity conservation across broad landscapes of complex social-ecological systems. The use of local tacit knowledge and participatory mapping represents rich contribution to help develop a unique and robust dataset for conservation planning, research and decision making. Using participatory research combined with geospatial technologies has provided a method to generate local tacit knowledge and represent its spatial components within a GIS, serving to enrich and address current gaps and limitations in formal-natural-science data and models. The contributed local knowledge provides insights into historical and current distributions, abundance and status of wildlife populations in the region, similar to findings elsewhere in NS (Cosham et al., 2016). The engagement of knowledgeable community members was effective for eliciting and incorporating social and ecological knowledge. As observed by a renowned farmer and naturalist in the region during the second workshop, the dataset that we have been able to create through the collaboration of a diverse group of local knowledge holders is probably “the best available data” for illustrating trends and patterns for this region (P5). There was overwhelming support and buy-in for the participatory process we used to

collaborate with local knowledge holders. The process incorporated a bottom-up approach, allowing for local participation, consensus building and the inclusion of local knowledge in the research.

The multi-directional learning relationships facilitated through our approach has led to increased awareness among participants about wildlife locations, populations, habitats and movements and threats to their persistence within the region. It has fostered and enhanced participants' interest and investment in conservation priorities across the Isthmus, providing a spatial focus for conserving key areas. Each participant created spatially-referenced maps representing their lived, individual experience by employing overlay drawing onto topographic maps. Together they identified areas of combined experiences, noting strong, validating consensus, and thereby gaining confidence in their knowledge and its potential use in decision making processes. Not only did the methods serve to elicit spatial data, but the maps served as a method to facilitate conservation knowledge sharing throughout the interviews and workshops. Participatory mapping has been commonly used to create 'sketch maps' for such purposes (Boschmann & Cubbon, 2014; Chingombe et al., 2015; Dunn, 2007). Our use of maps increased participant involvement during the interviews and workshops by providing an anchor for the dialogue to revolve around, furthering conversations and stimulating memories through the process, as was found by Boschmann and Cubbon (2014). Participatory GIS methods such as ours have been identified as serving to democratize research and planning processes (Barnett et al., 2016; Brandt et al., 2019; Canevari-Luzardo et al., 2017; Cutts et al., 2011) and build consensus between stakeholders and land use managers (Chung et al., 2019; Irvine et al., 2009). Knowledge exchange plays a key role in conservation management by facilitating the social, environmental and economic impacts of research (Cvitanovic et al., 2015, 2016). Not only is knowledge exchange critical to research during knowledge production and disseminating phases, but also during mobilization and translation for policy planning and decision making.

Inclusive knowledge systems and participatory mapping approaches such as those applied in this study can help to guide knowledge production and contribute to novel solutions to conservation challenges at the intersection of human and natural systems, consistent with findings in environmental management in general (Fry 2001; Revers et al. 2010; Brown et al. 2010; Berkes et al., 2016; Virapongse et al., 2016). Significant work has been done in the realm of PPGIS to operationalize concepts that bring social-ecological systems into spatial mapping frameworks (Karimi et al., 2015), and our study contributes to the field. Conservation planning

approaches recognize the need to embrace local knowledge along with formal science data and models and to utilize participatory methods to not only increase local participation, but to improve the validity of knowledge across spatial scales (Raymond et al., 2010). A critical step to overcoming barriers to knowledge exchange is improving access to information to allow the co-production of knowledge for use by decision-makers (Cvitanovic et al., 2015). Research such as ours facilitates local knowledge exchange and provides the opportunity to contribute to evidence-based decision-making in the region, responding within a timeline that can directly impact conservation planning, as urged by Lemieux, Groulx, Bocking, and Beechey (2018).

Local engagement and findings generated through our study are timely for supporting on-going work of NCC and partners in the NS-NB Community-Nominated Priority Place (ECCC, 2019), national efforts through the Pathway to Canada Target 1 Connectivity Working Group (Canada Parks Council, n.d.), the New England Governors and Eastern Canadian Premiers' Resolution 40-3[7] Working Group (NEGP-ECP, 2016), and the joint NS-NB and federal feasibility study on infrastructural adaptations to climate change (Smith, 2020), among others. Opportunities to put this information into the hands of the decision-makers and have the voices of key local people from across the region included within the decision-making process have been heightened through the research. The relationship between knowledge and decision making has become increasingly important in scientific literature recognizing that there needs to be a convergence of disciplines in order to properly address complex environmental management problems (Cvitanovic et al., 2015). Several contributions of the conservation social sciences, as outlined by Bennet et al. (2017), are highlighted throughout our research including facilitated learning of conservation challenges and the innovation of novel models for conservation through engagement of local knowledge holders. Our methods represent a generative effort to better enable and improve conservation data, models and planning. Such applications are vital to guiding processes with the best available and robust set of information (Bennett et al., 2017).

Collaborative approaches have been recommended to help improve evidence-based decision making, and this extends to conservation planning. Often, however, there is a disconnect between research and planning for conservation. To address the disconnect,

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7 Resolution on Ecological Connectivity, Adaptation to Climate Change and Biodiversity Conservation

research should match the evidence needs for conservation priorities (Lemieux et al., 2018). Our research comes at a timely manner to address current concerns in the Chignecto Isthmus region surrounding climate change, biodiversity conservation and infrastructural adaptations such as those to be addressed in the feasibility study on the transportation corridor. Sea-level rise poses a heightened predicament for the tenuous land bridge provided to people and wildlife through the Chignecto Isthmus. This threat highlights the need to think proactively about conserving and restoring wildlife habitat connectivity through this restricted land base, especially in light of current projects aiming to identify 'engineering solutions' to safeguard and adapt highway and other human infrastructure and other associated land-use pressures. Adaptations are likely to entail in-land relocation of some infrastructure, to higher elevations, and raised levels of others in place, such as roads and dykes, to remain above water in flood events and coastal inundation scenarios. Such adaptations are likely to further fragment habitat and restrict wildlife movement. On the other hand, engineered solutions, if planned with wildlife in mind, may provide heightened opportunities to mitigate barrier effects and other threats that infrastructure such as roads and wind farms currently pose to wildlife populations, habitat and movements.

Many known socio-ecological issues occur with human-wildlife interactions. Within the Chignecto landscape it is important to identify key wildlife conservation features (populations, habitat and movement patterns) so that they may be considered in conservation planning and infrastructural adaptation studies. Local knowledge has been shown to improve understanding of species distributions and impacting environmental factors, especially when recent shifts in these trends have occurred but are not yet captured in scientific data (Anadon et al., 2009; Austin et al., 2009; Cosham et al., 2016). Such up-to-date knowledge is critical in situations when timely conservation planning is required, such as in response to imminent threats (e.g., sea-level rise), sudden opportunities (e.g., infrastructure adaptation studies) and urgent priorities such as recovery of endangered species (e.g., NS Mainland moose) (Cosham et al., 2016; Austin et al., 2009). In our study and others (Austin et al., 2009; Silvano & Begossi, 2009), local tacit knowledge has proven successful in identifying species distributions, movement patterns and influencing features and processes within the study region, offering valuable information for planning and management.

While scientific data and models can reveal high-probability wildlife movement pathways or barriers to movement through the region, underlying factors as to what may be

attributing to these spatial patterns can sometimes be left to speculation. Model outputs such as maps are limited by the accuracy, relevance and completeness of the data and are influenced by the optimization rules that drive the analysis. Such model outputs are powerful tools, yet they largely remain out of context of the complex social-ecological systems. Local tacit knowledge can help to explain the underlying 'why' of certain phenomenon in a region: what external and acting factors are directly impacting wildlife movement pathways, pinch-point locations, roadkill hotspots and other phenomena? The local knowledge generated through this study therefore not only contributes to a more robust dataset but provides additional explanatory context for the patterns and changes. In the Chignecto Isthmus, for example, NCC's model detected land-cover types and roads based on the best available georeferenced spatial data and projected habitat suitability and potential wildlife movement pathways based on these data. Local participants enriched and complemented these data, expanding upon the impacts of landscape changes on wildlife, such as due to forestry practices, road access and traffic, water levels and siltation, as well as human activities such as poaching and wildlife interactions, such as between moose and deer. Local knowledge also effectively reflected accelerated changes. One participant (P29) noted and another (P30) concurred that since moving to the Chignecto Isthmus,

> P29: [W]e have really been recognizing just how important this area is because of animal movement, thinking how much small little sections of land are responsible for having to move so much land-based animals, and when you think of the type of traffic that's happening here …, the amount of change that we've seen in terms of development and car usage, it's insane.

Our findings provide cross-validated information for delineating priority wildlife habitat and connecting corridors within the Chignecto Isthmus. The process has fostered a diverse base of local champions for wildlife conservation. The next step is to disseminate and mobilize the findings to inform future decision making for conservation planning and land and resource management in the region for a long-term outcome of enhanced human-wildlife co-existence.

2.4.1 Limitations

Some limitations exist when using local knowledge in this study (Greg Brown & Kyttä, 2018; Corbett et al., 2006; M. McCall, 2006). There were moments when participants were hesitant to draw on the base maps in fear that the spatial data they would provide would not be

the exact location or area, or that they may be remembering certain events wrong. The "shifting baseline syndrome", a concept coined to explain knowledge extinction, occurs when the knowledge of the past is lost and the human perception of biological systems changes (Loftus & Anthony, 2018). As such the analysis may be limited by the accuracy and reliability of shared information. On the other hand, there was strong group consensus among the local participants and good agreement with NCC's formal science model and roadkill hotspots identified through roadside surveys (Barnes, 2019). Insights from the Mi'kmaq, if participants had been recruited, may have provided longer term insights, and most certainly would have enriched the diversity and inclusiveness of the knowledge emerging from such co-production.

As the livelihoods of many of the participants are linked to their knowledge of the land for hunting, trapping, farming and logging, the data could be seen as inherently biased. This may lead certain participants to talk more about a species than another. For example, a wildlife photographer enjoyed photographing black bears and much of the data represented areas where black bears may be spotted. As such, there is potential over-representation of certain species due to factors also recognized by Loftus & Anthony (2018): personal preferences for certain species, strategic choices in locations of travel, and the ease of seeing or noticing a species. When interpreting results for wildlife planning and management, it is important to take into account that the species and habitats are directly connected to the hobbies and livelihoods of the participants.

There are some limitations to using participatory methods to gather local, spatial data (Brown & Kyttä, 2018; Corbett et al., 2006; McCall, 2006). Fuzzy boundaries are prevalent throughout the data and it was sometimes difficult to discern class boundaries between mapped spatial phenomenon. Inaccuracies in the spatial data collected may result in inaccurate definition of classes and assignment of phenomena to a class, which may raise uncertainties about the precision of the data and ultimately impact decision making (Corbett et al., 2006; ESRI, 2016). How participatory data represents participants' and researchers' interpretations of certainty and ambiguity is important: fuzzy data should not be misrepresented as being precise and accurate (Corbett et al., 2006). Spatial reality in PPGIS is always fuzzy, and the accuracy and precision of data collected through participatory mapping methods when drawing on maps will also be impacted by factors such as scale and resolution (McCall, 2006). How to represent and interpret fuzziness was an important concept to frame for this study. A series of decision-making steps and guidelines were followed consistently when choosing how to classify points, lines and

polygons of mapped data into their categorical bins for mapping and representing spatial knowledge. Of course, this interpretation is unique to the classifier of data, using their best ability to accurately represent each participant's individual data.

In studies such as ours that engage relatively small numbers of participants in in-depth and qualitative explorations, questions may be raised about the representativeness of the sample and the generalizability and validity of the results. In our study, 34 participants with deep long-term experience of the region's land and wildlife shared their knowledge through interviews and participatory mapping. Eight of these individuals participated in two subsequent half-day mapping workshops. These participants likely represent a relatively large proportion of our target population—those with deep experiential knowledge of the land and wildlife—in this rural area: nearing the end of our recruitment phase, no additional referrals were emerging from our purposive, snowball sampling method. Near the end of the interviews, no new data were being contributed, which suggests that data saturation was reached. As a qualitative study, we were not aiming for statistically significant results or findings that may be stratified or generalized to the broader public. As such we are confident that the number of participants was sufficient to generate consensus-based insights about local knowledge on the subject. Although the participants represent a relatively small portion of the general public, their voices could potentially be disproportionately influential due to their knowledge base and locally recognized expertise. Now that they are more aware and confident in their insights as a consequence of participating in our research process, they are likely better positioned to influence local people and communities and related planning around wildlife, habitat, and connectivity conservation in the region.

2.4.2 Future research

While our study did not focus on assessing landscape changes due to climate change and related sea-level rise, some participants spoke to 'water' levels and temperature increases as potential reasons for wildlife declines and impediments to movements. Comprehensive studies assessing changes in water levels, temperatures and associated impacts on habitats and ecological corridors in the region do not exist. Similarly, impacts of forest clearcutting and forest roads on wildlife presence and movement pathways have not been assessed in the region, though many participants highlighted such relationships as a central concern, as did an independent review of forestry practices in NS (Lahey, 2018). Quantitative data on landscape

changes, irrespective of cause, similarly are not readily available nor to our knowledge have they been previously assessed at this scale. It is certain that the clearing of forests and construction of roads and dykes over the 400 or so years since Euro-American settlement have dramatically affected landscapes in ways that are important to wildlife, yet these have not been quantified in the region. In a petition to the colonial government in 1853, however, Mi'kmaw leaders expressed their concern with widespread changes throughout Mi'kma'ki:

> The woods have been cut down; the moose and the caribou, the beaver, and the bear, and all the other animals, have in most places nearly disappeared …. So that is it (sic) now utterly impossible for us to on Obtain a livelihood in the way our creator trained us[8] (as cited in Prosper et al., 2011., p.9)

To our knowledge, roads and dykes have not often or recently been 'relocated', per se, as a result of sea-level rise. Such complex inter-relationships and impacts warrant further analyses and some may well comprise portions of the 'engineering solutions' study currently being conducted in the region. In the meantime, our findings serve to enrich the social-ecological baseline data (while pointing out important gaps) so that future planning for road, dykes or other infrastructural relocation may avoid ecologically important lands, specifically those that are important to wildlife and connectivity.

More proximately, the next steps in our study aim to further develop inclusive knowledge systems and their engagement in conservation efforts. To further understand the interrelationships and patterns in knowledge from diverse sources, future research will explore the local knowledge data in relation to element occurrence records for key wildlife species compiled by the Atlantic Canada Conservation Data Centre (2020), forestry cover and roads, and model outputs of projected inundation due to sea-level rise. Forthcoming insights gained through our on-going qualitative, thematic text analyses of participant interview and workshop transcripts will be incorporated and shared. Improved understanding about how efforts such as ours that engage local knowledge can lead to local knowledge holders' support for conservation decisions that emerge from the knowledge sharing process would be beneficial. Important questions also remain about how efforts to engage local knowledge can lead those knowledge

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8 (Petition of Francis Paul, Gorman Paul, Louis Paul and others to Queen Victoria, 14 December 1853, C0127/213.ff.8-25,@19, PANS m/f 13, 1932 in Allen 2000, p. 111, as cited in Prosper et al., 2011, p. 9).

holders to further contribute to and participate in conservation efforts. In collaboration with participants, NCC and other partners, we will seek opportunities for engaging, disseminating and mobilizing the knowledges gathered through these processes for conservation planning initiatives in the region. Importantly, we will explore opportunities to build relationships and work with the Mi'kmaq, who have lived, deeply immersed, within regional ecologies of reciprocal sharing interrelationships for 15,000 years (Young 2016, 2018). Their title, rights, laws, governance systems, responsibilities, stories and ceremonies need to be honoured, and their insights would greatly benefit us all (Artelle et al., 2019; Young, 2016; Zurba et al., 2019). As signatories to the Treaties of Peace and Friendship (1725–1779) between the Mi'kmaq and Canada, we are all Treaty people (Nova Scotia Archives, 2020).

2.5 Conclusions

The Chignecto Isthmus is a critical land bridge between Nova Scotia and continental North America, providing connectivity for wildlife populations and human infrastructure. Coastal inundation and flooding due to rising sea level and storm-induced tidal surges threaten this already tenuous connection. Existing wildlife data from formal science sources are limited and insufficient for use in regional conservation planning or on-going studies exploring 'engineering solutions' for safeguarding and adapting human infrastructure. Accordingly, our study aimed to generate complementary data based on local tacit knowledge, while enhancing local understanding and capacity for engagement in these local planning processes. To do so, we engaged local people with strong experiential knowledge of the land and wildlife in the region to participate map-based interviews and workshops. Thirty-four local people who hunt, trap, log, farm, enjoy nature and others participated in individual interviews with map-based spatial elicitation tools to identify key areas of wildlife habitat and movement pathways across the Chignecto Isthmus. Individual mapped data were digitised, analysed and compiled into a thematic series of maps, which were refined by subgroups of 8-12 of the participants through consensus-based workshop processes.

Locations of key populations and movement patterns for several species were mapped, consisting predominantly of terrestrial mammals, primarily moose, black bear, and white-tailed deer, along with a group of other fur-bearing mammals and migratory birds. Strong consistency was observed among the mapped elements, resulting in group consensus despite some uncertainty expressed by individuals about their precision in noting the exact locations. When comparing local tacit-knowledge-based maps with those derived from formal natural science

data and models, a strong overlap was apparent. Not only did the local participants verify the formal data and model, but they highlighted areas and concerns outside of the model and their explanations lent complex social-ecological context to its mapped outputs. Further, their engagement in the process resulted in knowledge transfer within the group and increased confidence in their experiential knowledge and its value for decision making. The process also increased their support and buy-in for mobilization of the results for wildlife conservation and connectivity planning, particularly for addressing revealed threats to connectivity from forestry practices (clearcutting and herbicide spraying), roads, power lines, wind-energy farms, and increased water intrusion and flooding.

As such, our study has generated spatial and other wildlife data representative of consensus in local tacit knowledge relevant to wildlife connectivity and other conservation planning in the Isthmus region. The process represents a contribution to conservation planning methodologies, in which combinations of scientific data and local tacit knowledge are critically needed, both to provide reliable and locally supported information for planning and to open up the research and planning process to different ways of knowing and to local communities, in the spirit of inclusive knowledge systems. The findings are relevant to on-going decision-making processes and represent important wildlife information for incorporation into local planning initiatives, addressing gaps in existing formal science data and lending validity to the outputs of computer-based modeling of wildlife habitat and movement pathways. The consistency of data obtained from these local people represents an important outcome that demonstrates and supports calls for greater generation and mobilizing of local knowledge in the scholarly fields of conservation planning and participatory mapping.

Our findings contribute to the growing yet nascent body of literature at the intersection of conservation planning and participatory mapping as means of co-production of knowledge and inclusive knowledge systems. Importantly, it also accesses, generates, and makes available local tacit knowledge for conservation planning in practice, particularly for wildlife connectivity in a key linkage area identified as critical at local national and international scales. The findings enrich and complement data from formal natural science models, helping to address their gaps and limitations while providing important explanatory context. At the same time, our participatory mapping approach served to build local participants' confidence in their combined experiential knowledge and local support for conservation. It seems to have enhanced our

participants capacity to serve as local champions for infusing local perspectives of wildlife and other ecological and social values that warrant consideration in conservation and other planning initiatives, such as for human infrastructural adaptations to climate change. Our study demonstrates a way to help build a more inclusive knowledge system grounded in the people and place. It illustrates an effective approach for representing differences and consensus among participants' spatial indications of wildlife and habitat. It presents a means of co-producing knowledge in participatory mapping for conservation planning. Engagement of local people and their tacit, experiential knowledge of the land and its wildlife provides important insights and means to enrich natural science and foster conservation action for connectivity and human-wildlife co-existence, both of which are key to addressing twin crises of precipitous biodiversity loss and climate change.

CHAPTER 3 - Local Knowledge Holders' Relational Values for Wildlife

This chapter addresses the second objective of the thesis:

> Examine how local knowledge holders value wildlife and form human-wildlife relationships and whether and how these relationships and interactions might need to change or be harnessed for conservation initiatives in the region.

The first section introduces relational values in the context of social-ecological systems, outlining the history of relational values in the literature and describing Kellert's typology of human-wildlife values (Kellert, 1996a; Kellert, 2012; Ross et al., 2018), which I use as an analytical framework. Next, the methods used to apply the analytical framework to the interview transcript data are described. In the results, I demonstrate the values expressed by participants and how predominantly each featured across participants. Through discussion, I explore how well Kellert's typology applies to human-wildlife relationships in the current study context, how my results compare with others' using this framework, and how my findings may be of use in the conservation field, especially in the Chignecto Isthmus region. I then address limitations and suggest future research opportunities.

3.1 Objectives

This research seeks to explore the values held by local tacit knowledge holders in the Chignecto Isthmus region in relation to wildlife, to understand how wildlife are valued and why. The work fills an important gap in the literature on how and why local tacit knowledge holders value regional wildlife, and adds to the emerging literature on relational values, particularly those applying Kellert's typology as relational value. The findings should help to enhance understanding of local wildlife perceptions and support locally appropriate conservation approaches that reflect the place-based, social-ecological context. These findings are meant to complement previous and future research conducted on wildlife movement in the region (e.g. Macdonald & Clowater, 2005; Needham, Beazley, & Papuga, 2020; Noseworthy, 2014; Nussey, 2016; Nussey & Noseworthy, 2018), providing important information alongside traditional natural science, and addressing disparities in available resources and funding. The process of participating in the research may potentially mobilize local knowledge holders to engage in local conservation and management initiatives, especially within the context of recent transportation

engineering planning studies occurring due to sea level rise and failing dikes (Forbes, Parkes, & Ketch, 2006; CBCL Limited, 2009; Needham et al., 2020).

Accordingly, I examine local tacit knowledge holders' values surrounding wildlife as expressed within semi-structured, map-based interviews. Although interview questions intentionally elicited participants' experiential knowledge of wildlife but did not explicitly ask about their values, diverse relational values were nonetheless evident as embedded within their responses. I used Kellert's framework (Kellert, 1996a; Kellert, 2012; Ross et al., 2018) to interpret how the values inherent in human-wildlife relationships, according to this typology, were expressed by participants in their interviews. It is often difficult to quantify experientially-derived relational values because of how it may be near impossible to isolate singular facts or propositions (Fazey et al., 2006). Hence, qualitative methods are also crucial for understanding local experiential knowledge in its complexity. Yet, there are few published studies utilizing Kellert's value framework in analysis of qualitative data (except see Hunter & Brehm, 2004; Jones, Ross, et al., 2016; Ross et al., 2018), and none within this specific geographic context. This chapter serves as both an example and exploration of how Kellert's well-established relational value typology (as described by Ross et al., 2018) may be applied to qualitative semi-structured, map-based interview data, rather than quantitative survey data, and to elicit insights *a posteriori* from interview transcripts that were not originally intended for this purpose, as called for by Ross et al. (2018), thereby potentially providing novel findings and nuanced insights.

3.2 Theoretical introduction

Understanding the values created through relationships with wildlife and place is important for biodiversity conservation and management decisions (Folmer et al., 2013; Gosling & Williams, 2010). Understanding complex relationships among people and nature is especially important in social-ecological systems, where humans and wildlife co-inhabit natural and human-built systems (Jones, Shaw, et al., 2016). Wildlife conservation initiatives require collective collaboration and community participation (Bennett et al., 2019), and the Chignecto Isthmus region has local tacit knowledge holders willing to share their knowledge, as well as wildlife in need (Needham et al., 2020).

In Needham, Beazley, and Papuga (2020), we identified that conservation initiatives should be systems-based, taking care to "be cognizant of dynamic social-ecological interconnections between humans, culture, wildlife, and ecosystems that are influenced by

broad scale political, economic, and biogeochemical conditions" (p.6). The inclusion of these components requires collaboration between members of society, scientists, managers, and other key players (Virapongse et al., 2016). Wildlife conservation requires that various concerns are acknowledged and solutions to them incorporated (Beazley, 2000), and this includes the social, ethical, and cultural valuing of wildlife. Humans involved in social-ecological systems, through both individual and collective actions, "develop multifaceted relationships with the environment that strongly influence their views as to how natural resources should be used and managed" (Jones et al., 2016, p.1). It is therefore pertinent that these relationships, and the values they develop, are examined in order to understand what needs a community has when it comes to managing natural resources, extending to management of wildlife conservation initiatives.

Values exist within a system of cognitive hierarchy. Value orientation provides the foundation, which in turn influences beliefs and attitudes that affect intention and behaviour toward the environment (Fulton et al., 1996; Kluckhohn, 1951; Vaske & Donnelly, 1999; as cited in Jones et al., 2016a). Within the natural resource management literature, researchers have long sought to study values in different environments, and thus it is unsurprising that different categories of values have emerged. "Held" values are those which "represent ideals of what is desirable (Bengston, 1994), how things ought to be, and how one should interact with the world" (Jones et al., 2016, p.2). These are "generic, conceptual, and abstract" (Jones et al., 2016, p.2) values that are "principles or ideas that are important to people" (p.2), such as valuing beauty (of an environment or animal) or intelligence (in any species). Brown (1984) is often credited with first describing these values as "modes of behaviour", providing "the basis for preference judgements to be made" (Jones, Shaw, et al., 2016, p.2). Brown (1984) also defined both "assigned" and "relational" values that are now integral to studying human relationships with nature in environmental literature. Assigned values are shaped by held values, or modes of behaviour; they are attached to places, species, or other parts of the natural world, as well as to the activities that occur in these contexts (Brown, 1984; Lockwood, 1990; Jones et al., 2016a). An example of assigned value may be the importance attached to a birding area within a specific human community. Examining these values further, Brown (1984) posited that relational values describe the relationship between held and assigned values, "arising from the relationship between a subject and an object" (Jones, Shaw, et al., 2016, p.3). It is "relational values [that] underpin how one relates to the natural world in order to live a satisfied and fulfilled life" (Ross,

Witt, & Jones, 2018, p.47). An example may be that somebody who values intelligence (a held value) may then feel that crows are valuable because of their intelligence (an assigned value), leading to valuing direct engagement with this species (a relational value, such as affection or attraction). I agree with Himes and Muraca (2018) in the observance that valuations are not "entirely produced by the observer nor inherent to the thing but arise in the space of encounter where the subject and objects originate" (p. 2). Relational values not only connect the held (e.g., a person's worldview) to the assigned value (e.g., how much worth this place or object has for the person), but also illustrate the relationship between the person and the place or object, or in our case, wildlife. How the environment or wildlife responds may change how the person assigns a value or their relationship to it. This may in turn change social norms or interpersonal relationships, and further influence environmental, wildlife, and social responses. Because relational values are useful for explaining how people relate to nature while taking into account the shifting complexities of both nature and humans, understanding relational values fulfills an important role in the "coupling" of social-ecological systems (Ross et al., 2018).

Relational values assume that value formation is a reflexive system, where values are not rigid but are formed based on evolving relationships (Himes & Muraca, 2018; Chan et al., 2016; Jones et al., 2016). In the case of environmental relational values, these values are formed based on the fluctuating relationships between people and their environment that also take into account shifting social and cultural contexts. Relational values go beyond the traditional intrinsic/instrumental paradigm (Himes & Muraca, 2018; Chan et al., 2016) that is commonplace in natural resources literature, where instrumental values place value on ecosystem services (Himes & Muraca, 2018) and intrinsic values recognize the "inherent" worth of nature and wildlife, regardless of its "usefulness" (Pascual, Balvanera, Díaz, Pataki, et al., 2017; Sheremata et al., 2018). The examination of relational values allows for a deeper, more nuanced articulation of the complexities involved in social-ecological systems. Without including different types of value articulation, it is possible to overlook value assessments and bias the results of a value study (Himes & Muraca, 2018). Accordingly, pluralistic approaches that analyze or integrate more than one value and approaches that incorporate values shared by multiple people (shared values; Witt et al., 2019), are important to eliciting and understanding values for truly collaborative and effective conservation management and decision-making (Kenter, 2016).

Relational values are not inherent in things (whether they be nature itself, the environment, or the wildlife inhabiting it) but "derivative of relationships and responsibilities to them" (Chan et al., 2016, p.1462). With the rising popularity of relational values in ecosystem service and adjacent literature, various typologies and frameworks have emerged, seeking to interpret and analyze such values across environments and cultures (e.g. Hunter & Brehm, 2004; Chan et al., 2016; Himes & Muraca, 2018; Jax et al., 2013, 2018; Jones, Ross, et al., 2016). Kellert's 1996 typology predates the contemporary idea of relational values but comes after Brown's 1984 eponymous introduction of them, although Kellert first used the word "attitudes" to describe these values prior to greater acceptance of the cognitions inherent in human-nature relationships (Ross et al., 2018). Kellert's typology emerged from earlier work with Wilson (1984) who had developed the biophilia hypothesis that the two researchers then expanded upon (Kellert & Wilson, 1993). Through the biophilia hypothesis, Wilson and Kellert assert that humans have an innate biological need to connect and exist with and within natural environments, as has evolved over the course of human history (Kellert, 1996a; Ross et al., 2018; Witt et al., 2019).

Kellert's original 1996 typology included nine values:

1. Utilitarian (emphasizing how humans derive material benefit from nature);
2. Naturalistic (focused on the satisfaction humans gain from direct experiences and engagement with nature);
3. Ecologistic-Scientific (grounded in "the biophysical patterns, structures, and functions of nature" (p.13));
4. Aesthetic (humans having an appreciation for the beauty of nature);
5. Symbolic (the use of nature in human language, art, and thought as a means of communication);
6. Dominionistic (an urge to master and control nature);
7. Humanistic (a close emotional attachment to nature);
8. Moralistic (an ethical concern for the right and wrong conduct toward nature); and,
9. Negativistic (an aversion to, fear, or dislike of nature or parts of nature).

His earlier work focused on the relationships between humans and animals (Kellert, 1991a; 1991b; 1993, 1996c), he later moved on toward considering coastal environments (Kellert 2003,

2005) and children's spiritual development (Van Wieren & Kellert, 2013), and advocating for nature in the design of urban environments (Kellert, 2012). The strength of Kellert's value typology is that the framework encompasses a "range of emotional, intellectual and physical connections with environments" (Ross et al., 2018, p. 48).

Kellert's relational values are applicable across diverse situations, environments, and times, as evidenced by the decades-long empirical usage of the framework. It is an important framework for assessing human values as they relate to both wildlife and the environment. In this paper, we use Kellert's ten values (Table 1) derived from a combination of his original 1996 framework and later-career work that added 'Spiritual' and merged 'Neutralistic' with 'Negativistic' (Kellert, 2012; Van Wieren & Kellert, 2013), as synthesized by Ross et al. (2018). With values that focus both on the *meaning* and *benefits* derived from an ecosystem, the framework captures a more diverse set of values, going beyond anthropocentric ecosystem services to encompass more than just the benefits received by humans (Ross et al., 2018).

3.3 Methods of data analysis using Kellert's relational typology

A mix of inductive and deductive methodologies were employed to thematically analyze the textual content of the interview data. Emergent themes of human-wildlife relationships were identified both during and after map-based interviews, transcription and journal reflections, and through an initial inductive, open-coding process. Kellert's typology of values was then identified and chosen for deductive analysis because it serves to integrate valuations of knowledge holders' relationships with both wildlife and their habitat, the environment or nature. Kellert's typology has been used successfully in previous studies of human values toward wildlife (e.g. Hunter & Brehm, 2004; Weiss Reid, 2003; Kellert, 1991, 1993a) and has a strong foundation of empirical research (Ross et al., 2018). A mixed quantitative (counting how many participants expressed each value) and qualitative (coding values thematically) content analysis was performed, whereby transcript data were analysed according to Kellert's ten distinct value categories (Table 1), using Nvivo 12 Pro software (QSR International Pty Ltd., 2020).

Instances where participants spoke about wildlife at length or in depth were assigned to one or more of Kellert's value categories, with example phrases and quotes identified that captured the essence of the relevant value. Coded statements contained either an explicit or clearly implied association between wildlife and the underlying relational reason for the value (e.g., relating to participants' activities surrounding wildlife, or function of a type of habitat, or

effects of changes to the landscape, etc.). Accordingly, coded bits of text included only those wherein participants explicitly spoke about wildlife, or where it was clearly implied by the interview context (as demonstrated in the interview guide (Appendix A), researcher notes, transcript or audio recording). Instances of overlapping relational value codes among participants were quantified through a matrix query in Nvivo 12 Pro software.

As is the nature of discussions pertaining to wildlife's place within larger ecosystems, many responses contained entwined text about wildlife and the socio-ecology of the region. For this reason, coding categories included both Kellert's original 1996 values that were applied to attitudes towards animals and Kellert's 2012 values, as organized and defined as relational values by Ross et al. (2018) (see Table 1). This combination of values was used to capture the nuances with which participants shared their knowledge; participants did not always separate wildlife or their habitat from the wider environment or landscape, and thus using this amended set of values ensured participant responses were analyzed thoroughly. Ross et al.'s 2018 paper was instrumental in organizing the coding framework for this research, as it provided clear and concise definitions for Kellert's earlier and later career values, which, although largely consistent, did evolve as more empirical evidence was collected showing the utility and validity of this typology across situations and subjects.

Value coding was completed by one coder (myself). Having one researcher coding and elucidating findings allows for maximum consistency between value coding and interpretation (Witt et al., 2019). The following sections present the quantitative and qualitative results of this content analysis, outlining the predominant values present.

3.4 Results

Participants (n=34) expressed numerous values as they relate to wildlife and the landscapes they co-inhabit in the Chignecto Isthmus region, often expressing a plurality of values that evoke an array of emotionality, ranging from happiness and joy to anger and sadness. Many participants expressed multiple values, and all of Kellert's value types were represented across the participants (Table 1). The most predominant values were Naturalistic and Ecologistic-scientific, with nearly all participants expressing these values (n=34 and 33, respectively); the least expressed values were Dominionistic, Symbolic and Spiritual (n=7, 6 and 5, respectively). Results for each value type are presented.

Table 1. Kellert's values and examples of coded participant quotes

Kellert's value (1996, 2008, 2012), as defined and compiled by Ross, Witt, and Jones (2018)	Number of participants expressing the value (n=34)	Sample participant quote(s) illustrating the value
Naturalistic *Direct observance, experience, or engagement with nature*	34	P1: The deer are common, here. In fact, **I saw one this morning out here . . .** We have maybe a dozen deer at a time in here, in the, in the wintertime . . . that first apple tree, right there? It holds apples all winter and they drop off . . . . They just congregate underneath that tree and hang around . . . **Kind of neat, actually.** P14: Halfway up that hill - and the moose cross - you go up my driveway …, and just before you start up the hill, the moose cross there. **I saw them cross there 4 or 5 times.** P17: Northern goshawk. Uh, took us about 2 years to find out what it was. But, buddy of mine's camp, going to his camp, every time we went we'd get almost swooped by this bird! **And … we could take pictures of it, and it was protective . . . .** And it nested in the same nest for, I think it was, 3 years or so.
Ecologistic-Scientific or Reason *An understanding of nature, acknowledgement and understanding of the systematic structures, interrelationships between species, physical and biological attributes of animals*	33	P10: **[T]his piece of road is more detrimental than other particular pieces of road .** . . . I mean, any two-lane highways. Just, just the sheer traffic volume and everything. Sometimes you look back and think, God, how is an animal going across the - cross at night . . . **It's also a density dependent, too. Yeah, … if you don't have, you don't have animals in the area, obviously you're not going to have any animals hit by cars**. P17: Well, **anything that's a predator**, whether it be a bird of prey or a coyote, or a bobcat or fox, or even if you're in different parts of the country, if it's a wolf or anything, **they're gonna go where the food is . . .** So, a predator, as far as I'm concerned, is on the move. P27: **If you're a moose, you're going to tend to cross the Isthmus, this area, and through into the bogs. But also along the saltwater**, because they're - the deer, **the moose, the bear - are out here, getting the salt water, to get ticks off and de-flea and all this.**

Kellert's value (1996, 2008, 2012), as defined and compiled by Ross, Witt, and Jones (2018)	Number of participants expressing the value (n=34)	Sample participant quote(s) illustrating the value
Moralistic *A sense of responsibility of caring for environment and wildlife; ethical concern for nature; opposition to exploitation of nature and wildlife*	30	P13: **I think the right steps** [wildlife overpass] are being taken. And you know what? If it [overpass] doesn't work, **at least we tried**. **How can we move into the future without moose in Nova Scotia?** P21: Well**, I do continue to believe that forestry impacts are the largest factor of landscape change** and, by area involved and by numbers of individuals of all species involved, we would have to assume those are the biggest impacts . . . There are, there's some species that benefit and some species that don't. The ones that do benefit, we don't have to spend too much time thinking further about, I would say. **It's the ones that are sensitive to forestry that are a big concern**.
Utilitarian or Exploitation *Utilizing or materially exploiting the natural world.*	30	*Utilitarian* P10: **I do a little bit of trapping on the outskirts of those areas . . .** I'm not spending much time going in . . . It's just not worth it. There's just- just low numbers of everything. P31: Yes, yes. [I've been hunting and fishing] Since [I was] 12 years old. I was raised up in Northern New Brunswick and **we pretty much lived off of wildlife**. *Exploitation* P11: There's a lot of **poaching** going on that **I'm not into** P20: I'd do the same thing before I went to school, before they started the mill up: just go down there [to the river], in five minutes, and **I'd get my trout**. Well, those days is gone . . . **the pressure on fishing now** [is high]**.** No, back then hardly anybody would come up to the country. P26: And the guy from the DNR [Department of Natural Resources] says, he goes, 'Well, I can tell you why there's probably no moose in Nova Scotia' . . . . DNR has a robotic moose that they use for poachers, they set it up, and then they'll sit and watch it . . . . It was shot 47 times in 4 days. He goes, that's why there's probably no moose here . . . . **Somebody out here sees it, and word spreads like wildfire. Pretty soon everybody in the area is looking for this [moose], and as soon as they see it, they get it.**

Kellert's value (1996, 2008, 2012), as defined and compiled by Ross, Witt, and Jones (2018)	Number of participants expressing the value (n=34)	Sample participant quote(s) illustrating the value
Humanistic or Affection *Emotional attachment or affection for nature and/or wildlife*	22	P18: **What bothers me is seeing the poor things [deer] on the roads getting slaughtered. That's what bothers me**. . . . [I]t's a shame, but what can you do? I don't know what they'd ever do to stop it. P12: I mean, I could **get into birds, I could go on all day about birds**. P29: I'm coming down at night and they'll [northern flying squirrels] be swooping on the drive, and might just come down and we'll catch 'em in the headlights. And they'll be gliding in front of us. And it's really cool. **We love our flying squirrels.**
Aesthetic or Attraction *An aesthetic attraction to wildlife or nature; awe*	20	P22: Right there, it was a car ahead of me and it was foggy, well, misty. And all of a sudden, this cat ran between me and that car ahead of me, and **it was just so fast**, it was just bang, bang, bang and it was gone. And all the way to Fredericton **I kept saying, it was a cat, definitely a cat; long tail, cat face. It was big**! . . . . **and to this day I think I saw a cougar** . . . in my mind I might have seen one.
Negativistic or Aversion *Passive or active avoidance of nature or wildlife, antipathy toward nature or wildlife*	16	P20: I have a concern with what's taking place now . . . . An eagle hit a male pheasant over here in the field; come down and hit it, and it couldn't lift it. So, it tore that pheasant apart while it was squawking and ate it alive. **I ran to get the bowman, chase it off.** P24: This marsh right there, now, is filling up with beaver . . . I haven't trapped them in the last couple of years, it's just not worth it. But there's beaver: beaver everywhere . . . . And when you're in the helicopter **you can see the damage that the beaver are doing**, on the woodlots; like the trees, **big stretches of trees that are dead**. P14: [The] beavers [population issue] is worse [in comparison to muskrats] . . . . **they [beavers] ruin too much land**. And they flood the waterways.

Kellert's value (1996, 2008, 2012), as defined and compiled by Ross, Witt, and Jones (2018)	Number of participants expressing the value (n=34)	Sample participant quote(s) illustrating the value
Dominionistic *A need to master or control wildlife or nature*	7	P8: In terms of, like, deer hunting, and things like that, **I enjoy just the test of all your senses** . . . . **The excitement** is a piece, a part of it as well. P14: Well, **you gotta go to that side of the highway and cut some trees down** and let them [deer] . . . spend their winter over there. Keep them there . . . . Give them something to browse on. **Go in there with a chainsaw and knock some hardwoods down,** so that they'll feed on the tops, and on the old spruce.
Symbolic *Figurative expressions of nature or wildlife through images, language, and design*	6	P15: So, I guess this comes back to the biology behind it. Not that, deer are not endangered; not to say they're not important, but it became **a symbol of the corridor.** So, **the deer told that story.** What, I don't know if you'd call it a keystone species, not today, but I think it's a good indicator of why that corridor is important. P22: And, of course, we've **got the sandpipers out in Dorchester Cape.** Can't forget them. That, to me**, when I think of this area**, is **what it would be most known fo**r. P30: You basically have to look at it [system of wildlife movement and population growth/decline] as a living organism. **How do you keep the arteries flowing in a circulatory system?** And you know, how do you keep the diseases out?
Spiritual *Connection with nature or wildlife, spiritual meaning; feelings of transcendence or reverence for nature*	5	P13: Right, was like when **I felt like I was in the heart of the Isthmus . . . .** I thought that, of all the habitats that I've experienced and walked or snowshoed through, crawled through, here, like, ***this is something*. I felt this was the heart of it and I hope that it's for animals, too**. P33: If you could get younger people out - and not just younger people - if you get anybody out and **then try to have a connection**: **let them have a connection** and see that what connects to what. Like, that salamander connects to that; it doesn't matter how big a snake; you know, anything: it all starts down here.

Note 'Number of participants' indicates how many participants expressed each value according to the coding criteria; examples of quotes for each value type are provided alongside the value predominantly expressed in the quote

3.4.1. Naturalistic

All participants (100%) expressed Naturalistic values in their interviews, with wildlife and nature experiences occurring across local and larger regional environments as well as varying temporal timeframes. Often, participants connected these relational values to enjoyable experiences in their childhoods, typically indicating that they had developed or been given or learned these values, or been influenced or inspired to have them, through familial ties and shared activities immersed in nature.

> P22: So, when I was, probably, as young as two or three, **I think my youngest picture [photograph], I was out in the woods with him [father] and my mother**, staying at camps. And, uh, my brother, who is four years older than I, he and I would travel with my dad and some other people back in the woods. Anyway, I was just, **it was what I grew up in**.

Some participants experienced a *Naturalistic* relationship with nature through spending time hunting wildlife, alone or with family or friends. Although hunting wildlife is a utilitarian relational value, the enjoyment of spending time in the woods and the experience of solitude represent Naturalistic relational values.

> P12: I enjoy both types of hunting, **a little bit of solitude I think is good for people**. But uh, I have two sons who are interested in hunting, **so as they grew up, I spent a lot of time with them.**
>
> P22: I like, like my woodlot. . . . I've had the woodlot for about 20-some years, built a camp there, beginning about 20 years ago, built some tree stands, and **I have solitude up there, [especially] when there were deer**.
>
> P19: Well, I don't mind doing that [hunting camps] a night or two, **but when I'm going out it's just to be alone. Being alone in the woods, yeah.**

Such experiences or engagements over multiple times and through the years were at times expressed as "enriching" or as teaching participants something they could not have learned otherwise, at times developing into a "passion".

> P3: **All I know is that my experiences have enriched my life greatly with wildlife** and, uh, our natural world. It's, uh, … it has been a **passion** for a long time. And I think

growing up in the country is a part of that. Because it's a process that doesn't happen overnight. **It doesn't happen overnight**, the things that you **learn**, eh?

Naturalistic valuations of wildlife varied in scope, where for some participants the joy of encountering wildlife was due to an individual relationship a participant had with a specific wildlife individual, such as the case of Participant 18 and the bobcat he and his family fed on their front lawn that "stayed there a while" while they "took pictures of it". Others generally enjoyed encountering particular wildlife species, such as Participant 14, who avidly described watching deer and turkey vultures, able to reflect on their local populations and how their actions brought him enjoyment.

> P14: They [turkey vultures] roost in old barns. They are ugly looking birds. Have you ever seen 'em? . . . There was six of them on the peak of the barn one day, and I sit there for an hour and watch them. They're in old barns up there, and they're in the Cobourg Road, in the old road, in the old barn there, too.

Though many encounters were by-products of other activities, some participants, such as P26, expressed that they explicitly search for wildlife to encounter because of the joy it brings, especially through wildlife photography (see section 3.5).

3.4.2 Ecologistic-Scientific or Reasoning

Almost all participants (33; 97%) also expressed *Ecologistic-Scientific or Reasoning* values during their interviews. This was a prominent value type identified in passages, often reflected through an understanding of how a wildlife species, or group of wildlife species, interact with each other and what roles they play in the ecosystem, and within both natural and human-dominated habitats. Participant 11, for example, identified and valued the rabbit as an important prey species for coyote, and explained how a lack of rabbits impacted the coyote population:

> P11: [W]e don't hear of anything like coyotes as much . . . It seemed for a while they were squeezed right down the Mountview area of Sackville . . . . **There wasn't any feed left for them [coyotes], and all the rabbits were moved off or killed off,** and there just didn't seem to be a place, that they could set back up and flourish and stuff. And **the coyotes seem to, seem to go for the food** and keep coming toward, down into town more.

This valuation of the roles of wildlife, especially as connected to habitat, extended to an understanding of how regional habitat changes influenced by human activities are affecting various wildlife species, such as expressed by Participant 12.

> P12: I mean, **there's movement afoot**. There's a lot of species, like coyote and white tail deer, that have moved into urban areas. As well, as we all know, if you've driven to Halifax lately, you've probably had to watch out for deer . . . So, yeah, as far as birds go, I think **any bird that favours mature forest, there will be fewer and fewer of those guys out there as well** . . . [like] cavity dwellers and, uh, big breasted warbler are just some of the ones there. **They prefer old growth forest.**

Others, such as Participant 1, talked about how wildlife interacted with human infrastructure, such as overpasses, pointing to an *Ecological-Scientific* understanding of how these human-made structures affect regional wildlife species.

> P1: If they [wildlife] can find the overpass, I suppose [it's a good idea] . . . . [B]etween the Trans Canada [highway] and Shediac, there was one spot where there were trees on both sides, and now they're building a house there. You know, I mean, that's, uh, **it was the one spot on that road where there was habitat on both sides, for flying squirrels and stuff**. They like, they like to have, like to know there's a tree they can land on [LAUGHS]. So, I think, **flying squirrels, if I remember right, it's about 100 yards, I think, they don't like to cross anything**. I mean, obviously, they can't fly 100 yards; I think maybe 100 yards is what I've been told . . . I mean, logically, they'd want to know there's a tree there, closer than 100 yards . . . I guess same as a rabbit or anything else, likes to know there's a tree, something, within 100 yards, that they can get under.

Ecologistic-Scientific or Reasoning valuing of wildlife often included association between species and habitat type, such as the moose or pileated woodpecker with hardwoods or red fox with marshes.

> P7: Foxes, you see them all over the place. I see foxes**, red foxes; you mostly see them on the marshes out here**. Yeah, with big dens, and in the dikes and stuff like that. Oh, and you'll see them in the woods but mostly you see the red fox around the [marshes].

Many participants directly connected the types of habitats they themselves used and inhabited, either for hunting camps or homes, or for recreational activities such as riding off highway

vehicles (OHVs), and with the specific species they had encountered. Participant 11, for example, spoke about how he had seen moose using the natural-gas pipeline right of way as a throughway in the region and reasoned that they were likely travelling both ways between Nova Scotia and New Brunswick, and that these observations had occurred while out with his family on four wheelers (a type of OHV). These narratives of wildlife encounters and the ecological reasons behind their presence in an area often then moved onto reasoning about why a particular species may be currently less abundant, or why the participant thought the species, such as rabbits, may be "rebounding" (P16). Another participant (P6) spoke about how he had driven into his camp and seen small rabbits during an early part of a season, and mentioned that "then you don't see them anymore, but you see the bobcat, you see the coyote". He connected the presence of the predators with both the seasonal life cycles of the rabbits and the rise and fall in the rabbit population as part of a longer predator-prey-food-supply cycle. This displays how the participant values rabbits and coyotes for their *Ecological* roles as prey and predator species in the local environment.

Tacit knowledge holders in this study placed great stock in *Ecologistic-Scientific or Reasoning* relationships in valuing the habits of wildlife, often referring to knowledge they had acquired through their professional (e.g., P15, P21) or other experiences in the region, such as during naturalist gatherings (e.g., P5, who also referred to studies his friends had shared with him). These and other participants (e.g., P16, P13) acknowledged the use of scientific data and how it had informed their own knowledge. Some expressed that their knowledge did not necessarily have the systematic scientific rigor they associated with scientific and academic research; for example, Participant 16 was particularly hesitant to speak about his observations, often qualifying them by telling us they were not scientific.

There was a strong interest expressed in understanding the "why" of wildlife decline and "what" in the region may be causing this decline, stemming from participants' knowledge of the roles of wildlife in the systems and the impacts affecting these roles. Participant 12 mused about how the inundation of saltwater had shifted the character and role of a coastal grassland environment and, together with the mowing of hayfields adjacent to these saltwater-inundated areas, had likely caused a decline in populations of grassland birds that had traditionally nested there, such as the endangered bobolinks.

> P12: That's anything that's, it's actually below sea level, or at sea level. There's salt water coming over it a long time . . . . I would extend it [habitat area of importance] up here [on the map], too, for bobolinks. They're an endangered species of grassland bird and . . . . They're down here, too. And there's sod production up there and they mow it every 3 days, so it's only that high. Savannah sparrows can live there but that's about it. And when you get further up here there's more [woods] standing here, and that's good for more species.

Participant 32 spoke about the benefits of Ducks Unlimited Canada's activities for waterfowl in the region, and how the creation of these habitats was also likely benefitting other aquatic species, such as otters. Many participants (e.g., P5, P14, P19, P31) connected the ebbs and flows in deer populations to land management and forestry activities and how these create habitat and forage for deer. Participant 14 particularly advocated for more management on the Nature Conservancy of Canada's lands in the region to ensure deer would stay in particular patches of habitat and avoid crossing roads unnecessarily, connecting this knowledge (of their forage and habitat needs) with their movements across the region. Participant 16 also advocated that wildlife could share space with areas of forestry activity, citing the connections between forest growth post-cut and foraging behaviour of some species:

> P16: Yeah, you know, any time - we've been working around forestry for years, along with a lot of other locals around here - a**ny time you ever cut a piece of land, animals flock right to it, 'cause there's food there**. And in the wintertime, they eat the tops of the stuff you cut, and then the next spring that new bush comes up and they start eating on it.

There were some participants who recognized that wildlife may be affected by microorganisms or other sources of illness such as disease. The most commonly identified health issues were brainworm (*Parelaphostrongylus tenuis*) that is carried by deer and deadly to moose (Timmermann & Rodgers, 2017), ticks (winter tick, *Dermacentor albipictus*) mainly affecting moose (Timmermann & Rodgers, 2017), and sarcoptic mange (*Sarcoptes scabiei*) affecting coyotes and red foxes (Astorga et al., 2018). Participant 6 spoke about coyote populations developing mange after an explosive growth in population had brought more individuals closer together, which the participant assumed "made it worse". These sentiments of worsening diseases were echoed by others, oftentimes accompanied by anecdotes of

observances and interactions with wildlife that participants used as evidence for their ecological and scientific reasonings. These reasons manifest as "values" participants have for wildlife and nature that they have developed as a consequence of understanding these ecological roles and relationship. Participants valued some species (such as the rabbit) for their roles in the ecosystem as a valuable prey species, or valued hardwood forested areas for their usage as habitat by valued species, such as moose and the pileated woodpecker.

3.4.3. Moralistic

A total of 30 participants (88%) expressed *Moralistic* values in their discussions of wildlife, making it one of the two values (along with *Utilitarian*) that were the third-most coded across participants. The way participants expressed *Moralistic* values is consistent with Kellert's (1996, 2012) description of this value as one that expresses a universal ethical concern for nature, encompassing both species-specific and wider nature and environmental concerns. The moral concerns expressed by participants were often tied to the witnessed environmental degradation affecting regional wildlife species and their natural habitats. Participant 26 expressed moralism through his explicit action of no longer hunting the deer as a response to the regional population numbers declining, reflecting an ethical concern (as defined by Kellert 1996, 2012) for how hunting may further negatively impact deer populations. During the interview, this participant (P26) discussed the issues affecting regional deer populations, such as deforestation, and how he was opposed to them in light of how they were negatively affecting deer populations. He expressed an ethical concern that went beyond a *Utilitarian* valuing of this species, expressing concern for the species and disdain at local forestry practices, culminating in the action of declining to hunt in an effort to not contribute to further to deer population decline.

> P26: They, basically, well, one, **I gave up hunting deer because there is none**. Deer population is really in the crapper around here. And, so, I gave up on hunting them about 12 years ago.

Within *Moralistic* coding there was the emergent subtheme of concern over the perceived disastrous effects of habitat degradation on local wildlife species. This was reflected by some participants through their discussions of how the intensive activity of the forestry industry was a direct affront to wildlife and needed action to be stopped or reversed. Participant 3 recognized the effects of forestry practices and moralistically objected to them, stating how he

had personally fought against activity seen as morally reprehensible due to its negative effects on wildlife and the environment:

> P3: [Spraying and other forestry practices] destroys a lot of bird life, and it also takes away the habitat for the deer, rabbits, and other animals that forage on the hardwoods. **So those are issues that I've fought against.**

Participants also lauded the efforts of the Nature Conservancy of Canada (NCC) in the region, an organization which has had a regional presence for decades and has sought to conserve habitat through private land acquisition. Participant 10 valued the protection of land for the perceived goodness of this action, both for regional wildlife and the environment:

> P10: Because, I mean, the Nature Conservancy bought that piece of land, which I applaud them for that. That's, **anytime you can protect the piece of land from the onslaught of development can never be a bad thing**.

A sense of ethical responsibility featured prominently when participants discussed the moral responsibility of people slowing down to avoid wildlife collisions on busy highways, such as the Trans-Canada Highway in New Brunswick, leading to the bridge to and from Prince Edward Island. Some, such as Participant 10, insisted "you can't fix stupid" and was adamant that, although speed enforcement would be useful, it would likely not deter people from driving too quickly. Some, such as Participant 13, related the *Moralistic* idea of slowing down for wildlife to her father's experience as a transport truck driver and how he had taken care to avoid hitting moose. There was generally an undercurrent of unease when discussing the responsibility for wildlife mortality; participants agreed that it was humans driving too quickly who were causing the issue but expressed doubt that any action could be taken to alleviate the issue. Some, such as Participant 32, offered a hopeful suggestion of speed cameras, but even so was not confident these would do anything. The road mortality issue presented as a *Moralistic* dilemma that participants agreed on but could not identify a practical and effective solution to.

3.4.4. Utilitarian or Exploitation

Along with Moralistic values, the *Utilitarian or Exploitation* value was the third-most dominant throughout participant experiences, coded for 30 participants (88%). Motivations for *Utilitarian* values of wildlife included subsistence, economic gain, recreation, or spending time with others.

> P32: Yeup, it's [hunting] nice and enjoyable . . . it's good camaraderie and it's nice to get out. And if you're successful, you are; and if you aren't, then you aren't. C'est la vie.

> P6: [I] love the meat. I love the- I love the hunt, you know . . . And I have had, at the other camp, there was the camaraderie of a bunch of us, all of us.

> P8: I love the meat, too. I do a lot of release and catch. I haven't even kept a trout in years, and I still enjoy doing it. So, the food is definitely a nice reward for the experience, but it's probably not what gets me out there . . . [O]ne of the new kind of perks for me is actually connecting with my children.

Utilitarian valuation of wildlife was often connected to participants' experiences in childhood where this valuation was "passed down" or learned from family members, and where the enjoyment of the bonding experience it provides is also valued.

> P9: Yeah, well, for me, **it started when I was young**. So, it [hunting] was an **opportunity for myself to spend time with my father**, growing up and stuff, and it was the same thing for him: **it was passed down**- I think it was his grandfather. So, it was exposed to me young . . . . And I still hunt. **So, there's a friend and family connection, too, going with my father and stuff; so, I enjoy that, our time to kind of bond**. That's another piece to it.

Although most participants valued wildlife and ecosystems through their utilitarian or exploitation relationship, many also had strong views about acceptable limits to use. For example, many expressed the view that the use of wildlife should not "decimate" or exert undue pressure on their populations. They often valued the avoidance of over-exploitation, such as through poaching, and surmised that exploitation was the opposite of what they engaged in. At times this was supported by the participant explicitly stating they hunted "absolutely for food" (P19) to justify their actions as subsistence values, as distinct from over-exploitation, per se, or that they were avoiding wasting an economic opportunity "because it costs you money to go [trapping]" (P1). Participants recognized poaching as problematic, especially for moose populations.

P20: I think **the biggest problem over here is poaching** . . . Why is there no moose? There seems to be an abundance of moose in New Brunswick, just across the border. Why is there no moose in Nova Scotia?

P32: It's [moose hunting] illegal in Nova Scotia. So, you know, the public is now quite determined, I guess, to really rain on these guys' [poachers'] parade. Which, you know, why not? . . . there's nobody that I know of that's starving to death, you know? This day and age, … to go and do something like that, and, you know most, well, all, guys that I associate with in the outdoors would be quite perturbed if they found out [somebody was poaching moose].

The participants generally stressed that utilitarian or exploitation values do not necessarily imply unsustainable use but instead entail sustainable use. This may indicate that the participants' *Utilitarian/Exploitation* values are tempered by their other values, such as *Ecologistic* or *Moralistic*. Kellert (1996b) suggested that focusing on short-term benefits, such as the use of wildlife for meat and pelt, may lead to over-exploitation; however, our participants do not appear to have relational values that have shifted in that way.

3.4.5. Humanistic or Affection

There were 22 participants (65%) who expressed *Humanistic or Affection* values towards wildlife. Wildlife species were viewed by some participants as beings that inspired a sense of love and affection, with some participants expressing strong bonds with animals—"I love wildlife!" (P13)—and others reflecting more reserved emotionality surrounding their attachments to both wildlife and the lands they inhabit. Participants expressed positive emotional, humanistic connections to the wildlife species they frequently saw around their homes and camps, such as deer, flying squirrels, bears, bobcat, and birds such as the northern goshawk and blackburnian warbler. Often during interviews, it was the emotion with which participants spoke, rather than the explicit words used, paired with the topic at hand (i.e. wildlife encounters), that showed an expression of this value.

Most who expressed *Humanistic or Affection* values often did so through a mixture of words and emotive vocal and facial expressions. This is evident in the way participants spoke about some species, such as how Participant 18 focused on deer and how their deaths by predation from coyote affected him, stating it was a "hard, hard thing to see" but not explicitly stating it was sad or that it made the participant feel grief. Many interviews had an undercurrent

of emotions, such as empathy and sympathy for the deer that transcends the understanding that deer are a natural prey animal of the coyote. In some cases, relational affection for wildlife was developed through and connected to familial and cultural history, such as in the case of Participant 13 who associated moose with her cultural Newfoundland traditions and how she "proposed to my husband over a moose dinner." Even for such relatively new inhabitants of the region, the presence of wildlife such as moose promoted feelings of emotional attachment because of these personal histories. These experiences cross over with *Utilitarian* values, where deer and moose are consumed species but also ones that spark affection. Other emotional attachments to wildlife were based on the younger generation's thrill and love of encountering them, such as in this example with northern flying squirrels.

> P8: And if you knock on the tree, they'll stick their head out. Like, **the kids love it** because we'll just go and give it a big knock and the little squirrel will come out and look at us. Sometimes they'll jump out but sometimes they won't. But there's at least two families, some of them on my property, right here, off the lake.

In expressing their sadness for the state of some wildlife populations, several participants expressed grief toward the degradation of the environment and the effects on the wildlife.

> P10: Some of the waterways and things like that, for beaver and things, and you know going into those areas. I'm not spending much time going in . . . It's just not worth it. There's just- just low numbers of everything. So intensely, too intensively, managed for forestry. So, for instance, you know in this area . . . this is where that traditional deer yard used to be, right? . . . This was one of the biggest deer yards in southeast, in southeast New Brunswick. Yeah, and so that area is no longer basically supporting anything, you know. And so, yeah, it's, **it's really, really, sad to see the areas and see just how and what's happened with this forest area.**

Participants expressed strong emotionality in various ways, whether through speaking of how it made them feel, or by conveying sentimentality through speech cadence and body language during interviews. Their expressions reflected the bonds participants experienced with a type of wildlife, and their feelings when something affected the species they were emotionally attached to.

3.4.6. Aesthetic or Attraction

Aesthetic or Attraction values were coded for 20 (59%) of the 34 participants. Although some participants passingly referred to animals as "beautiful" (P14) or "powerful" (P26), the primary focus was often on other values the species held, and the other roles they may have contributed to or fulfilled in the ecological systems beyond their aesthetically pleasing appearance or demeanor for humans. Some, such as Participant 13, connected the awe-inspiring sight of a "crow-sized woodpecker" (P15) to the healthiest part of the forested ecosystem.

> P13: . . . I skied across the isthmus; and, so, I did see pileated woodpecker in what I considered to be, like, . . . the most natural, healthiest part . . . . So, there was a pileated woodpecker right here and I was really, I was really pleased to see it. Yeah, **they're beautiful, like, dramatic birds, for their size and everything**.

Often, this value was expressed through language indicating awe at the physical characteristics of certain wildlife species; some, such as the wood duck, were explicitly identified as "beautiful" (P14) but, more often, it was a recognition of the power of a species or some other feature that inspired awe, such as Participant 19 telling us of his friend's encounter with a great white shark while fishing for striped bass in the region. This sense of awe was not always captured explicitly in words, but oftentimes in the other ways participants expressed an encounter, such as through the breathlessness of Participant 22 when he regaled us with his story about possibly seeing the elusive cougar in the area, and also underscoring that "it was big!" in his excitement. Participant 26 expressed his *Aesthetic* appreciation in his quest to encounter bears, which are his favourite photography subject, while Participant 12 described his search for "beautiful birds" that others in the birding community had recently encountered. Many participants expressed awe at the beauty and power of wildlife species, connecting to wildlife through *Aesthetic or Attraction* values.

3.4.7. Negativistic or Aversion

About a quarter of the participants (9; 26%) expressed aspects of *Negativistic or Aversion* value, defined as "Passive or active avoidance of nature or wildlife, antipathy toward nature or wildlife*"* (Table 1; Ross et al., 2018). This relatively lower number is unsurprising as our research targeted tacit knowledge holders with deep and long-standing experience with wildlife. The coding of this value focused on expressed negative feelings and actions toward specific

wildlife species, often due to the activities of the wildlife or participants' perceptions surrounding the intentions of wildlife.

A prominent theme that emerged within this value is that participants often did not identify any negative feelings toward wildlife as coming from themselves, but rather identified wildlife negatively as a "nuisance" or threat to the local landscape or other species. Participants sometimes had negative feelings on behalf of another species they value. There were negative emotions expressed in connection with wildlife species that were adversely affecting favoured species, such as when they described the detrimental effects they perceived from an increased coyote population on their valued deer. Some (P2, P18) expressed negativistic values toward coyotes because of their positive affinities for their prey, deer, while another had negativistic feelings toward eagles due to their impact on fish (i.e., gaspereau), waterfowl and upland birds (P20). The species most often maligned was the beaver due to the landscape changes they cause, whether these were expressions of the participants' own negativistic values or those they perceived others to have. Often, this *Negativistic* association with detrimental effects on the landscape came from a perceived overabundance in beaver population, which Participant 31 characterized as "pollute[d]" with beavers, and which Participant 24 associated with reduced trapping because of currently low pelt value. Expressions of *Negativistic* values were often paired with *Dominionistic* values, wherein participants spoke of the need to control beaver populations to alleviate pressures on the environment and decrease occurrences of flooding caused by beaver activity:

> P31: We used to do a lot of **nuisance** wildlife: beaver dams; beavers causing issues; and stuff like that. . . . Fromm Swamp was one of our big areas that used to flood all the time. So we wound up **doing a lot of live trapping and removal** . . . . And another location is the Missaquash System. We did **pollute that system** quite a few years in a row **with beavers** and we had to stop because they started causing some issues with [it], **they were plugging it**.

The association between *Negativistic* values and coyote surrounded its increased presence and effects on deer populations through predation, especially on fawns. This was a more personal *Negativistic* valuation, wherein some participants, such as Participant 18, expressed strong negative emotionality toward the coyotes, calling them "terrible, terrible" due to their (natural) need to hunt deer. Although coyotes were sometimes positively associated

with participants' hiking, walking and other leisure activities, they were more often spoken about in opposition (or negatively) to what was viewed as "right" in any given situation. In relation to deer, the "right" action is for the coyote to leave its prey alone (at least when the participant is watching). This may represent a contrast or conflict with the Utilitarian relationship that participants, as hunters, have with deer. This dichotomous relationship with coyotes illustrates the anthropocentric angle some participants took; although acknowledging that coyotes had a right to hunt (*Ecologistic* value), some participants expressed discomfort at seeing other species they personally valued being hunted, such as the case of P2, who chose to protect a buck he valued from a coyote he encountered (*Negativistic* value). While it may be argued that the participant wanted to reduce competition from the coyote so that he may hunt the deer himself, this does not seem to have been the primary motivation in this case. Rather, it was out of empathy with the deer itself, and thus a *Humanistic or Affection* value. This serves to illustrate a source of conflict as conceptualized by humans that stems from affection, attraction or utilization (hunting) relationships, and that disrupts their *Ecologistic* relationship, such as acknowledging the predator-prey relationship or concern about impacts on the deer (or coyote) population or the greater ecosystem.

Eagles were also sometimes associated with the *Negativistic* value, where their increased abundance was viewed negatively, affecting other wildlife populations (such as gaspereau). But eagles were only prominently discussed negatively by one participant (P20), with most seeing them positively, possibly due to their general charismatic, aesthetic appeal.

The valuations coded under *Negativistic or Aversions* did not include an active avoidance of wildlife or fear expressed by any participants, but rather a negativistic emotionality or antipathy toward some identified wildlife species. Those participants who expressed a strong *Negativistic* emotionality toward wildlife, such as Participant 18 toward coyote, often did it due to a strong *Humanistic or Affection* relationship with another species, such as the deer. Beyond a personal *Negativistic* feeling toward certain wildlife species, some participants (e.g., P 13, 26, 27 and 31) discussed how the *Negativistic* feelings and actions of others may affect human-wildlife relationships in the region. These instances where participants recognized and elaborated on the *Negativistic* relationships of *other* humans and wildlife were not coded under this value as it was not the participants themselves that had negative relational values for wildlife. It is interesting to note, however, that they perceived it in others. For example,

Participant 31 elaborated on these types of human-wildlife conflicts, discussing how those moving into rural areas sometimes sought the removal of the wildlife that pre-existed in the area prior to their arrival.

3.4.8. Dominionistic

There were only 7 participants (21%) who expressed a *Dominionistic* relational value to wildlife. Few participants spoke of mastering wildlife for personal gain, although some, such as Participant 14, identified that he hunted because he was "eager to get that big one", while Participant 8 identified hunting as "a test of all your senses".

Most often, *Dominionistic* values in connection to wildlife were expressed in situations where participants advocated for the forceful control of a wildlife species, such as the focus multiple participants had on controlling regional beaver populations (P10, P24, P31) because of the perceived damage caused by beavers building their dams. This response to the damage, unlike a personal mastery of wildlife, was not explicitly linked by participants to personal feelings, but rather to an implied general consensus that, regionally, beavers were causing damage and required control.

> P24: The boys [wildlife technicians] **try to keep it cleaned out**, and I know they [beaver] got up this year, and he's got to tore it up again now. We also wonder if they [beaver] get up in there, and the beavers put the dam back in, and they try to get it back in . . . . And they're not worth anything right now, eh? So, there's not much [trapping] pressure on them.

One participant (P20) also called for the control of a perceived overabundant bald eagle population, which the participant perceived to be artificially high due to local efforts to feed the eagles. This perception of overabundance was only highlighted by this one participant, and was further connected to familial historicity of disputes with raptors over their family's chickens.

> P20: These damn eagles . . . they're pretty birds, and they have their place in the ecosystem, but they're artificially maintained. They're fed in the wintertime. Otherwise, some of them would starve to death and die and nature would take its course. But when you get to fooling with nature.

Although seemingly *Dominionistic* on the surface, and arguably also *Negativistic*, it primarily may be more deeply rooted in *Ecologistic* value, as the call for control is rationalized in the expressed desire to return to a more natural (less artificial) condition or process.

Overall, participants did not often express *Dominionistic* values toward wildlife except to advocate for the control of wildlife populations for either the benefits of humans or the wider ecosystem. At times, these imbalances were perceived to have occurred as unintended consequences of previous *Dominionistic* actions undertaken for other purposes, including control over the broader landscape.

3.4.9. Symbolic

Symbolic value was coded for few participants (6, or 18%), likely due to the literal and direct way in which many participants spoke about regional wildlife and their experiences with the species present, largely avoiding the use of symbolic language. Many participants related to wildlife in their daily lives through their activities, or through the observances and activities of others, or through the understanding of what role wildlife play in their environment and amongst each other. But some did value wildlife in a symbolic manner that further expressed their emotional attachments to wildlife and its connections to the landscape. Participant 13 recognized that the moose is a symbol "of Canada and Alaska," and expressed mild outrage that such a symbolic species was endangered in the region. For Participant 22, sandpipers were symbolic species in Dorchester Cape, a significant migratory hotspot for the semipalmated sandpiper.

> P22: And, of course, we've got **the sandpipers out in Dorchester Cape, can't forget them. That, to me, when I think of this area, is what it would be most known for**.

Another participant (P15) explicitly identified deer as a "symbol of the corridor" when speaking about wildlife movement in the region, connecting his *Ecologistic-Scientific and Reason* values with the *Symbolic* value of a recognizable and oft spoken of species. This connection attributes a type of representative symbology to deer, which, although not endangered, "told the story" of the corridor and its importance in the region. The use of a recognizable species as a regional symbol is in line with the idea of focusing conservation messaging and efforts on charismatic or flagship species, to garner adoration, attention and support from the general public while serving a conservation cause. These are examples of wildlife species serving as

symbols of place and culture and as extensions of emotional attachment to place, while also functioning as symbols or indicators of healthy (or unhealthy) ecosystems.

3.4.10. Spiritual

Although *Spiritual* values were not often expressed (5 participants; 15%), those who did acknowledge their relationships with wildlife in spiritual terms conveyed a deep sense of connection that transcended other values. Participant 13 passionately described what wildlife means to them as both *Spiritual* and *Symbolic* connections to the land. There was a notable reverence for the species inhabiting the land, and especially for the habitat that supports these species. Participant 13, with reverence and awe in her voice, described the central, old-growth forest area as "the heart of the Isthmus," where she had seen the iconic pileated woodpecker, and where she hoped and assumed there was home for other species that may have been pushed out from other areas.

Spirituality, or related religiosity (a connection to a particular religion), was not explicitly discussed by any participants, but was implied by some (P33, P14) in the relationships with wildlife they elucidated. The connections with wildlife and habitat that they described attributed values deeper and more imbued with meaning than could be explained by purely scientific, utilitarian, aesthetic or other values. Spirituality is difficult to concretely define, and thus researchers often define it as transcending rational or scientific explanation (e.g. Dayer et al., 2007). The coding for the *Spiritualistic* value was based on an interpretation of Kellert's (1996) examination of culture as influencing how people value wildlife and the environment, where he states that for some hunter-gatherers "spiritual identification with the living world, [is] unrelated to a calculated empiricism or a particular desire to prevent pain being inflicted on other creatures" (p.151). In essence, *Spiritual* valuation emerges on its own as a transcendence of rational, utilitarian, or scientific valuations.

It was oftentimes difficult to distinguish between *Spiritualistic* and *Naturalistic* values due to the complexity of defining *Spiritualistic* and because both *Naturalistic* and *Spiritualistic* values involve emotionality and connections with wildlife and associated environments. Within coding, *Spirituality* was distinguished from *Naturalistic* based on participant emotionality and intonation, which is difficult to capture in transcribed text. The bolded passage below, "but I can just feel the energy going right through me", is an example of an instance where this participant expressed reverence for the peace of the environment and an energy, not necessarily

explainable, felt by them. It is this sense of deeper connection and lack of explanation through entirely rational means that distinguishes coding for *Spiritualistic* values from *Naturalistic* or other relational values.

> P33: Yes, for me, … it's so peaceful and you can see so many things when you're walking . . . . [I]f you can get to the woods, and get out of that truck, throw those keys somewhere where you never see 'em, and you go for 2 or 3 hours, or 6 hours, or 'til midnight, you'll, it just clears your head, and it always has for me. Any troubles that I've had through life, doesn't matter what has been, if you can get out to the woods, hug a tree, do something. Put your, take your shoes off and walk in your bare feet. I can just feel, **lot of people laugh, but I can just feel the energy going right through me**. Like when you get up in the morning, you looked at the sun coming up over the Bay, yeah? **It's like a bolt of adrenaline just goes through you**. It doesn't matter if you're 0-, 2-years old or 100-years old. **And so, the woods really is for shade and peace and just seeing animals being able to move around.**

Relational values can be viewed as a system of values expressed in a relationship, whether this relationship is to wildlife or to a place (Ross et al., 2018). Participants expressed their perceptions of wildlife in various ways, valuing direct *Naturalistic* engagement or observance, discussing the sociocultural nuance of *Utilitarian* values, or expressing the perceived *Negativistic* impacts of species such as the beaver.

3.5 Overlapping values

Participants often expressed a plurality of values (Himes & Muraca, 2018), or overlapping values, when discussing wildlife and the environment. The relative prevalence of overlapping values is evident in the results of a matrix query (Table 2). The highest frequency of overlapping (pluralistic) values within the participant group are for *Naturalistic* and *Ecologistic-Scientific or Reasoning* (n=34), followed by *Naturalistic* and *Moralistic* and *Naturalistic* and *Utilitarian or Exploitation* (both at n=24). These were followed closely by *Ecologistic-Scientific or Reasoning* and *Moralistic* (n=22); *Ecologistic-Scientific or Reasoning* and *Utilitarian or Exploitation* (n=20); and *Naturalistic* and *Aesthetic or Attraction* (n=18).

Table 2. Matrix query results of coding for overlapping (pluralistic) relational values among participants

Kellert's values (1996, 2012) as synthesized by Ross et al. (2018) Values as coded per participant (n=34)	Naturalistic	Ecologistic-Scientific or Reasoning	Moralistic	Utilitarian or Exploitation	Aesthetic or Attraction	Humanistic or Affection	Negativistic or Aversion	Dominionistic	Symbolic	Spiritual
Naturalistic		34	24	24	18	14	7	4	2	4
Ecologistic-Scientific or Reasoning	34		22	20	8	6	4	4	3	2
Moralistic	24	22		13	3	7	1	2	1	3
Utilitarian or Exploitation	24	20	13		6	2	5	6	1	2
Aesthetic or Attraction	18	8	3	6		2	1	1	2	0
Humanistic or Affection	14	6	7	2	2		0	0	1	1
Negativistic or Aversion	7	4	1	5	1	0		5	0	0
Dominionistic	4	4	2	6	1	0	5		0	0
Symbolic	2	3	1	1	2	1	0	0		1
Spiritual	4	2	3	2	0	1	0	0	1	

Note Cells highlighted in dark tone, with white number font, are those with the highest frequency of overlapping (pluralistic) values within the participant group.

Overlaps between *Naturalistic* and *Ecologistic-Scientific or Reasoning* values often emerged when participants reflected on their *Naturalistic* observances or engagements with wildlife and used their experiences to understand, and appreciate, the *Ecologistic-Scientific* role or functioning of the species within the wider ecosystem. As an example, P6 shared that he had been observing wildlife through camera traps on his property and, through these longitudinal observances, had determined that some wildlife species were travelling parallel to roadways and so was able to share what likely movement pathways were through the region. *Ecologistic-Scientific or Reasoning* and *Moralistic* overlaps showed similar themes where some participants,

through their observances and engagement with wildlife, noted that wildlife populations in the region were in danger from human actions and thus the participants had to advocate for *Moralistic* actions to help preserve wildlife populations (e.g., P1 indicated that land secured by NCC was "a good thing" and connected that judgement to an observation that it is a "wintering area for deer"). Such judgements were also often interlaced with *Ecologistic-Scientific or Reasoning* valuations of wildlife and the environment, demonstrating an understanding of how environmental changes were negatively affecting wildlife, and thus actions are needed to help wildlife in the face of such changes (such as habitat degradation or loss due to forestry activity).

Overlap between *Ecologistic Scientific and Reasoning* and *Utilitarian or Exploitation* values was often expressed through participants' linking their *Utilitarian* actions to their understanding of the *Utilitarian*-valued species' movement patterns or habitat needs. Participant 10, while discussing the deer he hunts, recognized that forestry operations in the region were changing habitat, "definitely affecting deer" and that, if there has been this "big change and if it's changing deer, it's probably changing for other species as well". This demonstrates both a *Utilitarian* valuation and *Ecological* one, where deer act as a visible representative for other species that are also being affected by forestry activities. Overlap between *Naturalistic* and *Aesthetic or Attraction* was represented through participants remarking about enjoyable engagements they have had with wildlife in nature, or observances that have made an impact on them, and how the wildlife was "beautiful" (P13), or sometimes how the species inspired awe in them (such as when P22 shared the experience of encountering what could have been a cougar on the road, exclaiming "it was big!").

Overlapping relational values show the variety of participants interactions with and valuations of wildlife. They illustrate the plurality of values shared by each individual and across the group. Participants' descriptions of Interrelating values, including how these values have interacted and changed over time, reflect the reflexive nature of relational values, as they are formulated and shift in response to one another and to changing social and ecological contexts. Participants' relational values were formed through various relationships, as clearly displayed; for some, it was direct engagement with wildlife, for others it was a sharing of wildlife knowledge throughout a community, while others used mediating tools, such as cameras, guns, or traps, for a distanced form of human-wildlife engagement.

3.6 Photography as a method of developing human-wildlife relationships

While speaking about their interactions with local wildlife, there were multiple participants (n = 19, such as P2, P4, P26) who spoke of their experiences using photography, with some (n=4) using the "camera to hunt now" (P6). This transition to a photographic form of interaction may illustrate an evolution of the relationship or connection they had once had with wildlife, evolving from one with *Utilitarian* values to one of *Naturalistic, Aesthetic or Attraction*, and perhaps *Humanistic or Affection* values. It may show that some of these participants already have 'held' values such as for beauty, but that the assigned value evolved from one based on valuing a species for its subsistence or monetary value to valuing it as an aesthetic photographic subject. With this shift in assigned value, the relational value also shifts from *Utilitarian* to *Aesthetic or Attraction*, as the relationship between the person and the wildlife species transitions in response to the fluctuating context. As such, the practice of photography warrants exploration as an illustrative example of relational values as a reflexive system, fluctuating in response to shifting environmental and human-wildlife contexts, as described in the literature (e.g., Himes & Muraca, 2018; Chan et al., 2016; Jones et al., 2016). In the case of photography, some participants explicitly described a change in their practices and activities in relation to deer in response to the declining population status of deer. For some, they shifted from *Utilitarian* to *Aesthetic* relational values, on the bases of their *Ecologistic-Scientific Reasoning* surrounding the declining deer population and its causes, and consistent with their *Naturalistic* and *Moralistic* values. Such shifts may also reflect a more general shift in cultural norms, moving away from the utilitarian act of hunting in response to declining populations of valued regional species.

Some participants excitedly shared their photographs with us while relaying their experiences. This visual method was clearly an important way some participants connected with their environment and the animals co-inhabiting it, sharing this connection with us during interviews.

> P14: But I've given that [hunting] up, I take pictures now . . . Oh, just watch them, take the odd picture. There's a big deer yard over here, every winter. And you can sit here any day of the week and watch them cross in the morning to eat and go back in the afternoon.

P6: Yeah, up until about 12 years ago. I stopped [hunting] . . . just because there was really no deer around. There was a couple, and I just thought, you know, the few that around, come back or whatever, but they never did . . . So, I have four cameras, and they're here pretty much year round, so I've got files and files and files and files of photographs stored in it. . . . [I]t's just all here on the property. Yeah, pretty much on this land.

Although it was not ubiquitous across all interviews in which participants spoke of their photographic expeditions, those who expressed that photography was a replacement for their *Utilitarian*-focused hunting activities expressed a sense of change in the region and longing for what once was, expressing an emotionality connected to a *Moralistic* ecological grief. During discussions about how to help deer from being involved in road mortality incidents, P14 expressed how he no longer hunted as he did not like seeing the deer dead, especially because of how many he had seen die from road mortality.

P14: Oh, yeah, I used to hunt a lot, too. But I've given that up. **I take pictures now** . . . . **I hate to see the animals dead.**

For these participants, switching to photographing their subjects rather than hunting them is a way for them to directly reduce their negative impact and also increase their support for the wildlife communities they are so closely familiar with, illustrating the reflexivity of their relational values. They do so through individual actions of *Moralistic* conservation and, for some, inspiring appreciation for wildlife in others by sharing their photographs, such as on social media. This shift can be taken as a reflection of current wildlife populations: if subsistence-oriented wildlife users are concerned enough to transition to another method of connection, replacing their traditional utilitarian subsistence value with another, there are likely regional issues (such as over-harvesting of forest stands and high levels of wildlife road mortalities) that need to be addressed.

Clearly, photography, whether professional or recreational, is one way to shift the type of relational value while forming new types of connections with the subject, as demonstrated in this study. Some of our participants formed *Naturalistic* and *Aesthetic* connections with wildlife through a lens, switching from a *Utilitarian* value, solidifying their connections with wildlife. . This connection was not always a singularly personal experience, as some participants expressed they had taken wildlife photography with other people present. Participant 18 told us of the

time a family of bobcats were fed by him and his work crew, and how they had spent time together photographing the wild family:

> P18: Oh, I've seen them, right in the yard here last winter. Stayed there quite a while, we took pictures of it. Bobcat, a mother and the young ones, like just huge kittens. And this old porcupine, they were eating on that. It was there maybe a couple of weeks or more. They stayed there- and then we took the deer off the road, the carcass, and threw it out to them, and they eat them.

Some used photographs that were shared by others in the community as a way to gain information about local wildlife and stay informed of their habits, such as P11, who saw a local shop clerk post on social media (Facebook) about seeing "seven bears together", thereby connecting with their communities across digital realms. This form of community communication extends the notion of switching to wildlife and landscape photography as an individual act of conservation to one of communal care, where, through photography, community members share personal observations of landscape and wildlife trends, potentially influencing one another's *Naturalistic* and *Aesthetic* valuations. This is yet another demonstration of the reflexivity of relational values, shifting and fluctuating in response to environmental and wildlife trends.

Photography as a medium engages a wide diversity of audiences, as evidenced by the diversity of participants who participate in it; retired biologists and amateur historians (P15), hunters and trappers (P1, P6, P14, P32), as well as conservationists and naturalists (P2, P7, P13) all expressed a *Naturalistic* emotional engagement with pictures and the process of photographing wildlife, sometimes expressing an *Aesthetic or Attraction* or *Humanistic or Affection* valuation of their wild subjects. It is potentially a medium that may reach beyond those with already pro-conservation feelings and engage a wider audience, especially within an interconnected human community.

3.7 Discussion

3.7.1 How appropriate is Kellert's typology to human dimensions of wildlife research?

Using Kellert's values and understanding them as plural, relational values, this research builds upon the literature concerned with the relationship web that occurs between humans and nature, and by extension wildlife. Kellert's framework goes beyond categorizing these

relationships based on instrumental, intrinsic, held, or other non-relational types of valuations. While various forms and levels of values in the value hierarchy are important, human-wildlife relationships need to be more closely examined and considered in a relational context to understand the complexity of how tacit and experiential knowledge holders value wildlife. Kellert's framework, as evidenced in its use in this analysis, still holds contemporary value as a tool for identifying relational values expressed by knowledge holders toward wildlife and nature. It offers flexibility, allowing it to encompass a range of human-wildlife situations and environments. In social-ecological systems, where some humans may have more close encounters with nature than others, this framework allows their unique experiences to be captured and analyzed holistically. For instance Weiss Reid (2003) used Kellert's (1996) framework to compare and find the similarities between how Halifax and Digby residents valued wildlife, two different social-ecological systems where residents expressed both similarities and differences in wildlife values (see also Weiss Reid and Beazley (2004), for a published version).

What may require further research as to the applicability of this framework is how knowledge of these values can be used to improve management plans or conservation initiatives. Researchers such as Hunter and Brehm (2004) and Witt et al. (2019) have advocated for the use of these types of findings in creating discourse between managing bodies and local knowledge holders, but guidance and examples as to how to actually implement this suggestion are scarce. A potential first-step in using findings from this research, for example, may be to compare current conservation initiatives and natural resource management policies in the Chignecto Isthmus region with values expressed by local knowledge holders and identify how these do or do not align.

Using Kellert's framework to assess data collected through semi-structured interviews that were not designed to elicit elements of the typology proved both challenging and rewarding. Applying Kellert's framework for *a posteriori* coding required interpretation of participants' vocal and facial expressions to distinguish between some values, which was especially nuanced between *Aesthetic and Attraction* and *Humanistic or Affection*. Although coding was stringently applied according to the definition for each value (Table 1) it still proved challenging. Participants often used the same words to describe both emotional encounters with wildlife and those that were simply pleasing, using words such as "cool" or "neat" to describe either type of situation. In some instances, coding of such passages was supported by

surrounding textual context, while in others it was the emotionality present in the participant's voice on the audio recording and as noted in narratives recorded in researcher fieldnotes. In Kellert's original use of the framework (1996), the *Humanistic or Affection* value was often attributed to bonds with individual animals, most often with domestic animals such as dogs and cats. As the framework continued to be used in different research contexts, the definition for this value proceeded to include a more general affection for wildlife or nature. This may prove to be an empirical issue or oddity, as *Aesthetic or Attraction* may also include a degree of emotionality and affection for nature on the basis of its aesthetic appeal, and *Naturalistic* values also encompass a degree of emotionality present in human-wildlife-nature interactions. It is not necessarily clear where the distinctions between these values lie, and this coding did show overlaps between them throughout passages. It would be useful to distinguish between these values with follow-up prompts about why their encounters appealed to them, if this reasoning is not initially offered, but it was not possible in this *a posteriori* work.

Applying Kellert's framework to data that was not originally collected for this purpose also requires that the process of coding be especially stringent. The semi-structured interview guide did not include questions that focused solely, directly or explicitly on code values (such as surveys might). This is often the case in applying typologies a posteriori. Further, semi-structured interviews often generate wide-ranging responses and voluminous texts. This was certainly the case in this study, wherein the semi-structured interviews addressed questions tangential to relational values. Accordingly, strict discipline was and needs to be exercised in *a posteriori* coding to exclude textual content that is extraneous to the objective of the analysis.

3.7.2 How these results compare with others

This research found that participants all understood the greater interconnections between wildlife species, habitat, humans and their impacts on wildlife and habitat. This reflects findings of previous studies, such as those by Kellert (1987) and Weiss Reid (2003), wherein most people recognize that human wellbeing is dependent on the interactions of wildlife within their ecosystems and vice versa. All of the 34 participants expressed *Ecologistic-Scientific or Reasoning* values, showing that they understand these complex interconnections and engage with them in some way. There was also a high prevalence of expressions of multiple intersecting relational values, such as *Utilitarian or Exploitation* and *Naturalistic*, within single bodies of text and by individual participants (Table 2). However, there was some conflict expressed when participants recognized the *Ecologistic* values of coyotes, and their need to prey upon deer,

while also expressing *Negativistic* value toward coyote for this deer predation. In these instances, participants recognized that these coyotes had *Ecologistic* value but they stirred unfavourable feelings in the participants, even with this value recognition.

In our project, participants expressed overlapping connections among, or a plurality of, relational values (Table 2). For example, direct *Utilitarian* and/or *Naturalistic* engagement with wildlife often influenced participants' *Ecologistic-Scientific or Reasoning*, such as surrounding observed declines or other issues wildlife were experiencing. In some cases, this led them to adjust their *Utilitarian* relationship with animals to avoid contributing to their further decline, sometimes shifting to *Aesthetic* appreciation (such as from hunting with a gun to photographing) and demonstrating their *Moralistic* relational values. In other cases, *Negativistic* relational values with a species occurred alongside *Dominionistic* values as means to control it, such as in the case of trapping beavers to prevent flooding caused by beaver dams. In these ways, values supported and complemented, rather than opposed, one another and are reflective of the shared or pluralistic nature of relational values, as also demonstrated by Kenter (2016).

The presence of different values expressed across our pool of participants argues against the stereotypical consideration of smaller and rural communities as "culturally monolithic" (Skogen, 2001; Hunter & Brehm, 2004). Although not all of the region is rural (with Amherst and Sackville acting as the township hubs closest to the provincial borders), many participants live on the outskirts of these towns or in rural and agricultural areas of the region. Even though the participant group is somewhat homogenous in that they are all people with strong experiential/tacit knowledge of the wildlife and the land, they expressed varying relationships with wildlife. Some, such as Participant 18, expressed strong antagonism toward coyotes for hunting deer, describing the phenomenon as a "terrible, terrible thing", while others, such as Participant 13, welcomed the intelligence of the coyote as a hunter. Our participants did not value exploiting wildlife for meat or their pelts but, rather, often emphasized how they value the sustainable use of wildlife in the face of environmental changes and declines in wildlife populations. This, coupled with participants discussing how younger generations in the region have seemed less inclined toward hunting and fishing, may reflect what Manfredo et al. (2020) identify as a shift in values toward "self-expression, social affiliation, and egalitarianism over subsistence needs" (p.1551), and a shift away from hunting

as a cultural norm (Hansson-Forman et al., 2020; Hansen & Jensen, 2012; Ryan & Shaw, 2011)). Further study is needed to both confirm a shift in values and track the potential motivations for them in the Chignecto Isthmus region.

Both town residents and rural tacit knowledge holders in our study expressed multifaceted values toward wildlife, just as Hunter and Brehm (2004) and Kellert (2005) found in their research. Being able to voice these diverse values toward wildlife gives tacit knowledge holders the power to express the narrative in the region they know best, weaving stories of regional environmental change in with their personal behavioural and value shifts toward wildlife. This information has often been missing in studies of human valuing of wildlife (Ross et al., 2018), with most literature using quantitative surveys and focusing on biological studies and computer modelling of animal movement, overlooking the nuanced relationships influencing wildlife movement and abundance, including socio-ecological ones.

The findings of this research show that local tacit knowledge holders are invested in local wildlife, seeking *Naturalistic* and *Utilitarian* opportunities of engagement, or otherwise noticing wildlife in passing observances, and ruminating on such encounters and observances leading to *Ecologistic-Scientific or Reasoning* and *Moralistic* values and relationships with wildlife. These widely expressed values, along with the other prevalent *Humanistic* and *Attraction* expressions of emotionality may provide an avenue for engaging local knowledge holders in conservation efforts and incorporating their experiential knowledge. Experiential knowledge is deeply imbued with relational values that are important to understand in considering place-based conservation initiatives and management strategies, both for community collaboration as well as to include multiple forms of knowledge of wildlife and habitat.

Neutralistic was not in the framework we used and therefore was not coded, in accordance with findings in previous empirical research that it was challenging to identify as distinct from *Negativistic or Aversion* values. In a study such as ours, which purposefully engaged participants with strong experiential knowledge of wildlife and thus implies participants had an active interest in or repeated interactions with wildlife, it would be even more unlikely that instances of *Neutralistic* relational values would be expressed. Additionally, when the goal is to elicit experiential wildlife information from participants, it would be less likely that the responses would display *Neutralistic* values.

Dominionistic values were expressed through personal *Negativistic* feelings toward specific species that some participants thought should be controlled due to their impacts on other species and the environments they inhabit. Some participants expressed values that reflect Kellert's (2004) definition of *Dominionistic*, which is that "people can achieve feelings of self-confidence and self-esteem by testing themselves in nature" (p13). Kellert (1996, 2012) warned that a prevalence of *Dominionistic* values could lead to a lack of respect for wildlife or the environment. A lack of respect for wildlife and the environment emerged when some participants spoke about the beaver, oftentimes overlooking the ecological niche a beaver fills in the ecosystem, disregarding its natural place. It does not appear that participants were particularly keen on the changes beavers had wrought but were not insistent on always controlling its actions to prevent further damages (as perceived by humans) either. Participants, such as P31, recognized that the actions of controlling beaver populations in one area could lead to an imbalance in other systems, which would become "pollute[d] … with beaver".

Witt et al. (2019) found that spirituality or finding spiritual connections was one way of ordering information for participants, helping them find a greater order in a system not necessarily explained through scientific or ecological means. In this research, *Spiritual* valuation was an extension for some participants of their emotional bonds with species and the environment that included an innate understanding of how these species filled a niche in their environment, but one that transcended a strictly ecological or scientific understanding. *Spiritual* valuations did not always come from explicit expressions of spirituality, but at times they did. For example, Participant 8 did express a "spiritual connection" with the land through hunting activities with his father, and another (P10) referred to the woods as "my church". More often, however, spiritual relationship values were expressed as a way of ordering information the participants knew about the environment and the wildlife they encounter.

Participants in this research were keen to share their knowledge of wildlife, and coloured that knowledge with emotional nuance. In our study, we found that tacit knowledge holders were incredibly worried about the detrimental impacts of the forestry industry on a range of species, more so than the threat of climate change and the rising sea levels associated with it, and more so than habitat fragmentation in general and its multiple causes such as roads and other infrastructural developments. This concern is reflected in other research exploring values toward wildlife; in Raadik and Cottrell (2007), many of the Estonian islanders shared

concerns about habitat loss negatively affecting wildlife. These islanders specifically linked habitat loss as caused an overuse of natural resources to benefit humans; our participants expressed a similar concern when discussing detrimental forestry practices that, rationally, are for the benefit of humans rather than wildlife.

In their paper on perceptions toward invasive and non-invasive species in Cape Horn, Schüttler, Rozzi, and Jax (2011) suggest that local knowledge should be considered as a source of information alongside other scientific information. And just as in our research, Schüttler et al. (2011) found that local knowledge can be used alongside scientific knowledge, providing new and nuanced insights. Beyond these insights, we also found that participants enjoyed speaking to each other about their interactions with wildlife, which not only provided us with insights but also allowed for participants to build on their emotionally laden knowledge. Kellert (2004) had suggested that strong emotional feelings could transition into strong feelings of loss due to environmental spoiling or degradation (as cited in Witt et al., 2019). Participants actively expressed deep feelings associated with the loss of regional habitats and wildlife populations. This form of emotional bonding over nature, sharing the same values, may strengthen human community ties (Kellert, 1996), a communal strength that is essential if collaborative conservation initiatives are to be successful to combat the effects of habitat loss paired with climate change.

3.7.3 Implications for conservation in the region

Shared feelings between community members toward mutual goals are integral to the success of conservation initiatives (Sueur et al., 2020). In our research, we found that familial and other communal bonds were strong and present throughout interviews, with values shared across participants. Similarly, Jones et al. (2016) recognized that community bonds and a shared sense of “love” for place (in their case, rural waterways) are important in targeted natural resource management efforts. Shared communal values are reflected in how observances and information are shared across communities, either through direct contact (e.g., encounters with other humans and storytelling and sharing of experiences of camping and hunting) or through the use of online intermediaries (e.g., photography, social media sites, groups for local online communities). These observations and information will reflect the inherent biases of individuals both transmitting and receiving this information, thus informing how people relate to one another, wildlife, and nature. As an example, if simple observances are shared without value-

laden commentary, then the conveyed relational value with wildlife may be neutral or positive. But, if negativistic values are shared, this may influence communities to see wildlife as negative, such as in the case of beavers building dams that cause flooding or coyotes attacking deer, similar to the findings of Ross et al. (2018) around groundhogs digging into lawns, or deer eating lawn plants. Evidence of emotional engagement with nature being promoted by the process of photography was prevalent in our research, consistent with the findings of Hanish, Johnston, and Longnecker (2019). In our study, relational values were expressed through photographing wildlife using active camera capture as well as passive trail camera capture. The wide net of participants interested in photography suggests this visual method may help to elicit emotions and values useful in understanding community needs for conservation initiatives. By helping people make *Humanistic* emotional connections to wildlife through their communal bonds, such as by engaging in the act of photographing wildlife or simply viewing wildlife photographs, may promote pro-conservation behaviour, as also suggested in other studies (Jacobs & Vaske, 2019; LeDoux, 1998; Kellert, 1996).

Amongst our participants, we found that mutual experiences of wildlife in nature also served to form and strengthen bonds among people. This is consistent with the findings of Witt et al. (2019) in their study of Kellert's values in Australian waterways, that emotional connections with other people were "formed or strengthened through their interactions with nature" (p. 646). Whether through familial or cultural historicity, participants expressed that it was the presence of nature and/or wildlife that mediated their relationships with other humans. In many cases, these experiences provided a way to deepen their shared histories on the land. Observance of changes in wildlife populations and habitat occurred *over time,* as participants visited the same places on multiple occasions, strengthening emotional bonds through repeated exposure and engagement. Wildlife was identified as an essential part of an ecosystem whole, illustrating the concept of systems thinking, defined "as a way of thinking and understanding that considers the elements, interconnections, and function or goal of things" (Mahajan et al., 2019, p.2, citing Meadows, 2008).

Both individual human narratives and larger sociocultural histories play important roles in the formation of these relationships for participants. Many participants expressed personal and cultural connections to regional wildlife species, whether it was through direct encounters with wildlife starting during their childhood years (Participants 2, 3, 10, 14, 20), hunting and trapping various species (Participants 1, 8, 9, 15, 17, 19, 23, 31, 32), or the consumption of

moose as a practice that reminded them of home (Participants 13 and 19). Our findings reflect what other researchers in the human-wildlife interaction sphere have posited, that "human interactions with wildlife are a defining experience of human experience" (Nyhus, 2016, p. 144). Human-wildlife relationships and interactions form significant parts of the human identity and inform their perceptions of wildlife (Peterson et al., 2009), making them important to understand for the development of effective conservation measures.

The wide sharing of common values provides an opportunity to bridge divides and make space for collaborative opportunities, as Kellert (1996; 2004; 2012) and other scholars (e.g. Pascual et al., 2017; Ross et al., 2018; Birendra et al., 2021) have also recognized. This is especially important in wildlife conservation initiatives where people may come from different backgrounds, with different understandings of what the issues are and how to solve them. It is also important to examine these values to go beyond stereotyping communities, especially rural ones, for holistic understanding of how communities value wildlife and how this can be emphasized and integrated toward conservation goals (Frank et al., 2015; Manfredo et al., 2020). As I and others have found, natural sciences provide necessary data for making conservation decisions but do not necessarily provide sufficient data or the whole picture (Jones et al., 2016; Needham et al. 2020). Knowledge of wildlife movement and abundance may be greatly enhanced by experiential knowledge of local people; but crucially, their insights may help us to better understand how they and other community members may support or react to conservation initiatives that intersect with their relational values with wildlife and the land and other socio-ecological factors like their livelihoods and communal bonds and entanglements.

Through the findings, I concur with Kellert (1985), who argues that it "may seem reasonable to focus attention on preserving large geographic areas essential to the survival of imperiled species" but that focusing on species may be both an emotional and ethical necessity (p. 532). For conservation in this region crucial for terrestrial wildlife connectivity, it is important that communities, planners and managers pursue a multi-species approach of focusing on a suite of species that include regionally imperiled and important species (such as moose) as well as those who are not endangered but produce strong positive emotions in local knowledge holders, such as deer and black bear. It is also important that conservation initiatives include messaging that highlights the ecological importance of species that many consider a nuisance, such as beaver, and predators, such as coyote. These species are functionally important in

regulating ecosystem landscapes and trophic structures, and support for their presence in the landscape should be fostered and enhanced.

If conservation initiatives are to be fruitful and successful, they require support of the communities within which they are taking place (Bennett & Roth, 2015; Waylen et al., 2010). The tacit knowledge holders of the Chignecto Isthmus region may be willing to engage with their communities, whether this is through the *Utilitarian* uses of wildlife acting as a means of cultural and community connections, *Ecological-scientific* understandings of the function of wildlife, or deeply held *Moralistic* belief and *Humanistic* compassion that the wildlife in the region deserve the help and need assistance from humans to recover. This analysis of how local tacit knowledge holders value wildlife shows the complex and iterative relationship between human-wildlife engagement and both individual human narratives and larger sociocultural histories. It is important to account for the various relational histories and shared values expressed in the Chignecto Isthmus, which must move toward a collective and collaborative approach of keeping both human and wildlife inhabitants safe in the face of rapidly changing landscapes, climate and other associated threats.

3.7.4 Limitations

Three key limitations were encountered during this analysis. First, the pool of participants was generally limited to older, white males (with the exception of four female participants), skewing toward an older age demographic. This is a limiting factor in that conclusions may not be generalized to the broader community. Although participants had a range of tacit knowledge regarding wildlife in the region, it is likely that our data collection captured a narrower range of experiences than would be anticipated within a broader cohort. This limitation may be addressed in future research through the targeted recruitment of female participants, younger participants, and Indigenous participants. However, the objective of our study was to examine the knowledge of those with strong local experiential knowledge, and it is to be expected that such in-depth experience would be more prevalent among people with a longer lived-experience on the land, and those who tend to have land-based vocations, many of whom are men. Further, by virtue of their interests and knowledge about wildlife and habitat, this cohort may comprise those who are likely to engage in conservation activities, which may be useful from a direct collaboration perspective with agencies. It is likely that many Indigenous knowledge holders would also have strong experiential knowledge of the region. Unfortunately,

pragmatic delimitations were set to not explicitly target Indigenous recruitment due to the longer-time frames needed to nurture respectful research relationships, which would extend beyond the timeframe of conducting master thesis research, particularly in the absence such pre-existing relationships (for an overview of ethical considerations in relation to research with Indigenous peoples, see Bull et al., 2019).

A second limitation entails the method of sampling for participants, which combined purposive sampling with snowball sampling. Some participants were recommended by others and thereby knew each other and may have been more likely to share common values, despite encouragement to share names of others who may have different experiential knowledge. This is similar to the limitation listed above and suggested methods for addressing it are the same, such as by targeting recruitment at other communities and demographics.

Third, as mentioned previously, the semi-structured interview guide for this research was not designed to explicitly elicit relational values, and thus not all content was useful for this purpose. Researcher interpretation was required to determine which questions and passages may address the study objectives related to assessing relational values. This could be addressed in future research by explicitly structuring an interview guide to elicit relational values surrounding wildlife and their habitats. However, as suggested by Ross et al. (2018), the application of Kellert's typology to data collected for other purposes is warranted to "elicit more nuanced understanding of relational values" (p.50). Further, if participants are prompted about certain values, they are more likely to express them, and thus potentially introduce bias in the results. Our findings show that Kellert's framework is effective for distilling more nuanced understanding of relational values from qualitative data collected for other purposes.

3.7.5 Future research/next steps

The analysis of values in our pool of participants proved both revealing and intriguing, and also illuminated some potential future lines of research. In their responses to questions about and discussions of wildlife, participants often illustrated an emotional connection to place, or place attachment. Place attachment is both the emotional bond between a human and place as well as how individuals "view themselves in relation to their environment" (p.436), and how these two interrelated concepts may develop from and lead to the development of "functional relationships with a place" (Folmer et al., 2013, p.436). Place attachment was expressed through participants speaking about their love of solitude in the woods, how bonding

with other community members occurred on the land, and other connections formed with place, either through human or wildlife relationships. Although not explored in-depth in this research, it would be a worthwhile endeavor to revisit the Chignecto Isthmus region and explore the relationships tacit knowledge holders have with the land as 'place' and how this reflects in their knowledge of and relationships with wildlife. There is an iterative relationship between relationships with place (between humans and place), and this relationship extends toward wildlife inhabiting these places both through direct interaction with wildlife inhabiting the landscape as well as the symbolism placed on wildlife and its relationship to place (Greg Brown, McAlpine, et al., 2018; Folmer et al., 2013). Emotions that are felt toward place extend to wildlife and directly influence how the wildlife inhabiting the landscape are viewed by humans (Wieczorek Hudenko, 2012; Amit & Jacobson, 2017).

Connections to land have been previously explored using Kellert's value framework (e.g. Kellert, 2005; Hunter & Brehm, 2004; Witt et al., 2019) and thus the framework has empirical proof of its utility in exploring these values as they express parts of sense of place. But, as Witt et al. (2019) identified, "place" is perhaps a type of object "that a relational value can incorporate" (p. 652), and thus it is unclear how much further nuance can be drawn through using Kellert's framework in exploration of sense of place and place attachment. Although it provides a jumping-off point, it is likely worthwhile to explore other frameworks that include relational values, such as the Intergovernmental Platform on Biodiversity and Ecosystem Services' (IPBES) framework (Pascual, Balvanera, Díaz, Pataki, et al., 2017), for examining sense of place in the Chignecto Isthmus. The IPBES framework incorporates intrinsic, instrumental, and relational values as a means of examining how nature benefits people, moving beyond a framework that disproportionately focuses on the economic values of nature (Díaz et al., 2015; Himes & Muraca, 2018).

Tacit knowledge holders base a lot of their information not only on their own direct observances and experiences, but also on those of their families, friends, and communities. These observances and experiences are shared between community members both in-person but also through the use of online social media communication tools (e.g. Participant 11 spoke about a Facebook group where information is shared about the negative effects of glyphosate spraying in the region). It is a potentially important area of research, in an era when fewer people may have the opportunity to directly experience nature due to increasing urbanization,

to examine whether online communication of wildlife declines may influence people in the same way that direct observances and interactions do, and how the high chance of encountering false information online may further influence valuations. Many of the tacit knowledge holders of the Chignecto Isthmus region have longitudinal experiential knowledge on the ebbs and flows of wildlife population cycles in the region, but this information is not necessarily able to be collected or internalized by everybody, especially by those who moved into the region during or after widespread and intensive habitat changes, or those who do not have the opportunity to spend as much time outdoors as the participants. The use of online communication tools may serve as an opportunity to both collect longitudinal information in lieu of direct nature experiences and share these experiences with newer community members.

3.8 Conclusions

This study sought to examine and elucidate the relational values local knowledge holders of the Chignecto Isthmus have with local wildlife species. This analysis has shown that Kellert's framework of values, though conceived decades ago, still has application in contemporary contexts. Its strengths lie in capturing the complex ways in which individuals and groups of people develop and express relational values with wildlife and nature, which can provide important information for planning and implementing locally relevant, socially-acceptable and thereby more effective wildlife conservation initiatives. As with Kellert's early work, this study with tacit knowledge holders of the Chignecto Isthmus region shows they value wildlife in a variety of ways, but strongly value direct engagement and observances of wildlife, understand the connections between wildlife species and their habitats, and are concerned for wildlife and the environments they inhabit. Using relational values in conservation and natural resource research, such as in this study, can help to provide social context (Chan et al., 2016; Witt et al., 2019) crucial to ethical conservation research and practice. Regional wildlife is ubiquitous in the lives of local knowledge holders and so there was much to be learned through speaking to those with substantial experience. The results present a rich, complex picture of how participants and wildlife interact in the region and how this has been influenced through sociocultural histories.

Participants had deep familial and cultural connections that utilized wildlife but also transcended strict material utilization to encompass other values and adhere to the ethics of sustainable use and not over-exploiting wildlife. Tacit knowledge holders of the Chignecto Isthmus form strong bonds within their communities and communicate actively about wildlife,

sharing knowledge, emotions, and connecting experiences. These experiences are often shared through the visual medium of photography and social media platforms, eliciting emotional reactions to wildlife even at a distance, which may help to foster aesthetic appreciation and humanistic attachment and thereby increase and broaden community support for wildlife conservation.

This research shows that local knowledge holders also hold *Ecologistic-Scientific* knowledge alongside their *Naturalistic, Utilitarian, Moralistic,* and emotional attachments to wildlife, understanding the detrimental impacts occurring in the environment as connected to their valued species. Local knowledge holders value wildlife in nuanced ways that should be heeded for successful conservation initiatives inclusive of community collaboration.

Through this research, we were able to examine how local knowledge holders value wildlife and form human-wildlife relationships using Kellert's tested framework. In exploring these values, we found that human-wildlife interactions and relationships could be harnessed for conservation initiatives in the region by reflecting local knowledge holders' values in these initiatives, and how there is further work to be done to thoroughly explore the nuances of human-wildlife relationships, especially in geographic-specific social-ecological systems such as the Chignecto Isthmus region. Using Kellert's framework, this research not only adds to the body of work on wildlife movement, population fluctuation, and mortality issues in the region, but also contributes to the literature on successfully using social science for biodiversity conservation.

CHAPTER 4 - Conclusion

This research has elicited local tacit knowledge holders' perspectives about wildlife populations, locations, and movement patterns, issues affecting wildlife, and how they relate to wildlife in the Chignecto Isthmus region. We achieved this through: (1) semi-structured interviews, conducted *in situ* at locations of the participants' choosing, whether this was in their homes, or in public places they frequent; followed by, (2) two in-person workshops with a subset of knowledgeable participants, hosted within the study area, in which we discussed the preliminary and refined results in map format, thereby eliciting further input and feedback. The collection and analysis of these data and generation of results together comprise a process of co-production of knowledge on wildlife in the region. The previous chapters have explored the context, methods and results for this research, including the patterns and values associated with wildlife in the Chignecto Isthmus region as shared by local knowledge holders in their chosen localities. This chapter serves as a means of processing and interpreting this shared knowledge in an integrative way, within the context of human-wildlife interactions and relationships and exploring further potentialities for knowledge sharing and research in wildlife conservation.

4.1 Achievement of research goal and objectives

The goal of this research was to explore local tacit knowledge of and relationship with wildlife, wildlife locations, and movement patterns in the Chignecto Isthmus region, so as to co-produce wildlife knowledge and contribute to the database of wildlife and environmental knowledge in the region. This was achieved using mixed qualitative methodologies in ways that engage the participants' autonomy, agency, and values, and thus reflect their local perceptions and knowledge. To accomplish this goal, my objectives were as follows:

3. Examine how local knowledge holders perceive wildlife, their distribution and movement patterns, changes in these patterns over space and time, and reasons for these changes, and;
4. Examine how local knowledge holders value wildlife and form human-wildlife relationships for better understanding of local values, in order to better inform wildlife conservation measures in the study area.

Objective 1 was addressed in Chapter 2, a co-published paper, which examined how local knowledge holders perceived wildlife populations, locations and its movement in the region, and the issues regional wildlife face. Chapter 3 explored local knowledge holders'

relational values of wildlife using Kellert's (1996, 2012) wildlife/environmental values typology, and discussed them in the context of conservation measures, achieving Objective 2. Using Kellert's 1996 framework, it was found that participants valued direct experiences with and observations of wildlife, using these experiences to understand what could be affecting regional wildlife populations and movement, and how human actions were negatively affecting some species. This analysis also showed that many of those who utilize wildlife, whether for economic gain or for subsistence, value the sustainable use of wildlife, and also expressed nuanced understandings of how human actions could negatively affect wildlife. This bodes well for conservation initiatives in the region, as it illustrates that local knowledge holders of the region understand what is affecting the species they cherish, providing a base of knowledge from which conservation practitioners, land managers, and other involved parties can draw and build upon for successful biodiversity conservation. The current chapter explores how the perceptions and valuations of wildlife by local knowledge holders lend themselves to inclusive knowledge systems, examining them in the context of knowledge co-production at both local and larger scales of conservation, incorporating the findings of previous chapters. This chapter concludes with reflections on the methods used in this study, the limitations of this research, potentials for future research, and a final summation of the most significant findings of this research in the form of key conclusions that this research achieved.

4.2 Inclusive knowledge systems and co-production of knowledge

Community buy-in is key to effective knowledge dissemination and mobilization for conservation (Bennett et al., 2016). Our project achieved buy-in through local knowledge holder participation throughout the research process, ensuring that knowledge was both shared individually and co-produced, leading to the generation and dissemination of co-produced knowledge. This process of co-production led to the emergence of themes both in spatial representations of wildlife data (Chapter 2) and in values expressed toward wildlife and regional environments (Chapter 3). Combined, the identified themes comprise discrete parts of a larger body of local tacit knowledge converted into more a formalized form and thereby available for dissemination. Together they co-create a cohesive picture of wildlife patterns and human-wildlife relationships in the Chignecto Isthmus region. The growing rate of landscape disturbances caused by humans, namely destructive forestry practices, growth of human infrastructure such as roadways, and anthropogenic climate change, have affected regional wildlife and its movement. The effects of habitat loss are particularly noticeable in the mainland

moose populations, whose populations have been low for decades, igniting concerns in researchers and local people alike. These concerns are well-documented in formal scientific research in the region (e.g. Beazley et al., 2005; Snaith & Beazley, 2004) as well as in research incorporating local knowledge of wildlife (Macdonald & Clowater, 2005). Notably, more than 15 years ago, local knowledge holders in Macdonald and Clowater's (2005) project also recognized that a lot of suitable moose habitat in the isthmus region had been lost or degraded through destructive forestry practices, knowledge that was shared repeatedly by our own participants throughout our project. These findings help to explain and add richness to natural science and computer-based models of wildlife patterns and provide information crucial to conservation initiatives, in terms of local values and support.

In Chapter 2, thematic maps were presented that represent participants' perceptions of wildlife species presence and movement, and signs of conflicts that wildlife encounter, such as roadkill, as generated through individual interviews and follow up workshops. During the workshops, participants noted that there was a general agreement in spatial representations of these data across participants. Participants generally concentrated on ungulates in the region (deer and moose), hare/rabbit, other hunted and trapped furbearers (such as beavers and otters), and black bear. Participants were concerned about how habitat degradation and fragmentation could be affecting species in the region, especially with detrimental silviculture practices affecting forest composition and density. There were identified roadkill hotspots, especially along Highway 16 in the region, that corresponded with previously identified road mortality hotspots in Macdonald and Clowater (2005) as well as recent roadside surveys (Barnes, 2020). There is also the notable finding of how the pinch point in the computer modelled maps that essentially "funnels" all modelled wildlife movement at the border of Nova Scotia and New Brunswick generally aligned with the observations participants had mapped, displaying how both local knowledge holders and formal scientific practitioners share some of the same concerns and observations of wildlife locations, movements, and patterns in the Chignecto Isthmus region.

In Chapter 3, participants' relational values surrounding wildlife were presented, as derived from their stories of wildlife as recorded in interview transcripts. Participants expressed multiple relational values toward wildlife, coded according to Kellert's 1996 and 2012 value frameworks, oftentimes colouring their wildlife stories with sociocultural nuance and deep

emotionality. The findings show that all participants expressed *Naturalistic* values toward wildlife, underscoring how participants value direct interaction and observation of wildlife that involve their beliefs as to what is affecting wildlife presence, movement, and mortality. Almost all participants also expressed *Ecologistic-Scientific or Reasoning* values, displaying how knowledge of the roles of wildlife, and that which may be negatively affecting these roles, connect to the larger picture of the Chignecto Isthmus region and the changes occurring there. *Moralistic* and *Utilitarian or Exploitation* values were often expressed. Participants were outraged and dismayed by the habitat degradation and continuing negative human influence on the landscape, feeling passionately about helping to preserve biodiversity while lamenting the limitations of what can be done. While many did express that they utilized wildlife, they also recognized that there were acceptable limits to use, condoning sustainable use as understood to be maintaining the balance of species in the region, and opposing over exploitation. These shared values and experiences of wildlife were found to potentially strengthen bonds between humans, laying the groundwork for shared communal concern as to the potential decline of regional wildlife species and their associated habitats.

Through incorporating agency into our methodologies that allowed participants to speak about the species and areas important to them, and recognizing the need to integrate local, tacit knowledge with formal scientific knowledge, we were able to collect and explore nuanced qualitative and spatial data as related to regional wildlife and local landscapes. The following sections will explore the findings of these chapters in conjunction with one another and what they might mean for conservation measures in the region. The prevalence of social-ecological systems thinking and diverse relational values will be examined to further understand how our participants thought about wildlife and their mapped data as related to regional wildlife.

4.2.1 Social-ecological systems thinking

In this project, participants all displayed evidence of social-ecological systems thinking when it came to discussing the patterns of and issues plaguing wildlife in the region (Chapter2). Throughout the interviews there was a strong and consistent focus on the detrimental effects of anthropogenic landscape changes in the Chignecto Isthmus region, especially as they affect the population, distribution, and movement of wildlife species across the region. During workshops,

participants also collectively recognized these negative effects and further discussed their implications for regional wildlife populations.

Many participants responded in ways illustrating that they understand the complex interactions between fauna and flora species of the region, such as by presenting their thoughts in a systems-based manner (i.e. looking at the ecological whole) as opposed to focusing on any single issue or species. This was especially evident in the emergence of overlapping relational values, where participants expressed a mix of *Naturalistic, Ecologistic-Scientific or Reasoning, Moralistic* and other values, illustrating the complexities of human-wildlife relationships within the region (Chapter 3). Just as Hunter and Brehm (2004) found that their rural participants expressed complex values toward wildlife, so did our participants illustrate their multi-faceted values towards wildlife and the environment. Social-ecological systems thinking was represented both through the way participants discussed information, recognizing the ecologistic-scientific ways wildlife fit and worked within larger social-economic systems and landscapes, but also in how participants recognized the utility of this research. Some participants acknowledged the importance of this research in providing contextualized co-produced local information that told the whole story and therefore could be beneficially utilized in communications with land and wildlife managers and the general public and in regional biodiversity conservation initiatives. Bridging the knowledge-action divide by inviting local knowledge holders, scientists, land managers, and other parties involved in conservation to the table is integral not only for sharing knowledge but to cooperatively act upon it as well (Cooke et al., 2016).

Although many participants often focused on the same subset of species inhabiting the region, such as deer, moose and black bear (see Appendix B), the issues affecting their regional populations were linked to complex and larger-scale landscape and climate change influences that were also affecting other species. The participants in this research innately understood and expressed that the status of wildlife varies across species depending on the participants' relationships to each other and the landscape, and their responses to various biological and social-cultural influences, in complex ways. For example, they often spoke of the ebbs and flows in populations of species as related to their roles as predator or prey; their relative resilience or sensitivity to human activities such as forestry, roads and removals; and how everything is

connected. This reflects systems thinking as defined by Sterling et al. (2010) in relation to biodiversity:

> . . . biodiversity can be seen as a collection of complex and dynamic systems requiring systematic understanding that accounts for connections among seemingly disparate biological and cultural components. Beyond identifying the parts of the system, we need to understand how they link together, and to characterize their dynamic interactions and emergent properties (p. 1095).

Participants demonstrated this systems thinking through mapping wildlife movement pathways and mortality areas while associating these with habitat and obstacles. Multiple species were identified as moving through the region for different reasons, with paths converging at the border region between NS and NB, consistent with previous wildlife pathway modelling work in the region (Macdonald & Clowater, 2005; Noseworthy, 2014; Nussey, 2016; Nussey & Noseworthy, 2018). This type of thinking was also present in their discussions of species and the complex interactions among species and with the environments they inhabit, especially when noting longer-term regional changes to the landscape, through human infrastructural developments, activities, and climate changes.

Wildlife issues were closely tied to landscape change; detrimental landscape change was identified as having affected the region for over 30 years, while many participants from both NS and NB identified that the last five to 10 years had been most negatively impactful. Some participants linked negative effects on wildlife to climate change (without distinguishing between natural and anthropogenically-accelerated), and others to human activity on the landscape, such as disturbances in forested areas and changes of tree stand composition and hydrologic systems. Others also spoke of trophic cascades, although not in as many words but by associating the decline of suitable habitat with the decline in prey species (e.g., rabbit/hare) and with the subsequent decline of their predators (e.g., coyotes and foxes). In their research on whether Nova Scotian adults prefer dykeland maintenance or wetland restoration, Sherren et al., 2016 found that many of their survey respondents seemed to have a "lack of knowledge of the complexity of the issues" (p.276). In our research, some participants expressed hesitancy as to the accuracy of their claims (especially when it came to mapping wildlife spatial data), but many often displayed complex understandings of how wildlife and environmental processes are linked in the region, exploring the connections between effects of climate change, human

effects on the landscape, and wildlife movement and population fluctuations. This insight into how participants spoke about their experiences in the Chignecto Isthmus region as related to their concerns about wildlife populations and movement patterns further supports the idea that addressing issues in the region in a holistic or systemic way, combined with a focus on specific species of high relational value, may serve to better address issues in the region and further involve a community that is concerned with different parts of the ecosystem. This is supported by research that has focused on stakeholder involvement or local knowledge integration in conservation (e.g. Farwig et al., 2017; Virapongse et al., 2016), where a holistic systemic view received more stakeholder support as opposed to focusing on a single species.

Separating out any one issue from another would in some ways do a disservice to the nuanced picture painted by this study of local knowledge of the Chignecto Isthmus region. By placing emphasis on the Chignecto Isthmus region and the species that use it,, there is the potential to foster a stronger support base for conservation strategies across the region and enhance understanding among local knowledge holders, scientific and management professionals, and the general public.

4.2.2. Social-ecological systems and relational values surrounding wildlife

As identified in both Chapters 2 and 3 of this thesis, the Chignecto Isthmus region is an example of a social-ecological system where humans and wildlife live side by side. As we found in our research, there are daily interactions between humans and wildlife that lead to nuanced human-wildlife relationships, as evidenced by the multiple values participants expressed toward wildlife while mapping similar movements patterns across species and between participants. All participants drew from multiple experiences with wildlife and the land to discuss the patterns in wildlife movement and map it. Some focused on their emotional connections to wildlife and how the loss of wildlife species was and would affect them, while others focused on how changing wildlife patterns and populations could affect the sustainable utilization of wildlife by local knowledge holders. Social-ecological systems are complex and encompass various relationships between humans and environment, humans and wildlife, wildlife and their environment, and wildlife with other wildlife. These complexities emerge when local knowledge holders have the opportunity to share and co-produce knowledge about their interactions with wildlife and the environment, highlighting potential issues and areas of concern, such as road mortality hotspots. Land and wildlife management organizations can and should use frameworks that encompass the different parts of local knowledge-holder data in the process of

informed land-use and planning decisions that accommodate both humans and wildlife, accounting for their complex and place-specific needs.

The results generated by applying Kellert's (1996, 2012) value typologies to the participants' accounts clearly illustrates the plurality of values held by local knowledge holders in the region. Using this framework, and others that similarly explore a wide breadth of values connected to wildlife and the environment, would likely prove useful in bridging the gaps between management, scientific, and tacit-experiential expertise in a manner that emphasizes the meanings humans place on wildlife and their shared environments (Jones et al., 2016). Kellert's typology may be used in natural resource planning and biodiversity conservation, as it interprets and organizes values into a framework that helps to generate information as to what is most important to knowledge holders in a specific place or region. In our research, participants placed high emphasis on direct interactions and experiences with wildlife, valuing *Naturalistic* and *Utilitarian* experiences, while also demonstrating *Ecologistic-Scientific or Reasoning* surrounding the value of wildlife, particularly their roles as predator and prey; and, they connected their values with sociocultural histories and concerns for wildlife declines, including *Moralistic*-based concerns. Carter et al. (2019p. 398) make the explicit connection between the diversity of experiences in human-wildlife interactions and the complexities involved in an SES framework. Through the incorporation of these systems of values within natural resource planning and conservation in the Chignecto Isthmus region, and understanding that local people express a simultaneous multiplicity of related values toward wildlife, it is more likely that the initiatives will be successful, consistent with findings in other local communities (e.g., Waylen et al., 2010).

Participants often expressed emotional connections to wildlife and the issues they face (especially when they are similar to human issues that are concrete and identifiable, such as loss of wildlife habitat that also results in the loss of woodlands enjoyed by humans recreationally). At times, they acknowledged that this had led them to take actions consistent with conservation. For example, worries over declines in deer and other species prompted some participants to switch to hunting with a camera rather than a gun. This is consistent with reports in the literature that emotional connections can enhance cooperation and support for conservation initiatives within the communities inhabiting the affected region (Waylen et al., 2010). As documented by Sherren et al. (2020), wildlife was a focal point for Nova Scotian farmer stewardship motivations and motivations were often intrinsic (e.g. a need to protect

wildlife and its habitat) as opposed to extrinsic (e.g. motivated by payment from stewardship programs). Although they did not explicitly focus on emotional human-wildlife relationships, the authors did note that literature shows “farmers exhibit positive attitudes towards wildlife” (Sherren et al., 2020, p.261); these intrinsic motivations may be a reflection of positive feelings, perhaps emotions, toward local wildlife. Illuminating these types of positive attitudes or emotions toward wildlife may be especially effective when paired with conservation or management frameworks explicitly recognizing and utilizing relational values in social-ecological systems (Arias-Arévalo et al., 2017; Jones, Shaw, et al., 2016).

Alongside values toward wildlife, our participants demonstrated personal and familial connections to the landscapes of the region that influenced their relationships with both the wildlife inhabiting it and the environment itself. Local knowledge holders in the region have consistently demonstrated connections to the land, such as in Sherren and Verstraten's study (2013), where many farmers had a long experiential history on the land and "demonstrated a deep personal connection to agriculture in the region" (p.74). Using a relational values framework, which integrates both wildlife and environmental values that may stem from such rich familial and sociocultural land-based histories, to understand the nuanced shared worries about wildlife and environmental decline in a community can provide the community with a concrete rendering of their concerns. This acts as a communication bridge between the community members, potential planners, and others involved in conservation, infrastructure planning, and climate-mitigation strategies.

This concrete rendering was evident amongst our participants during the workshops, wherein they encountered their shared concerns, felt validated through this realization, and expressed interest in ideas and actions to address them. Using physical base maps during both interviews and these workshops were integral in eliciting these concerns for wildlife and the environment while providing participants with validation in the process of knowledge co-production.

4.3 Maps as mediators or boundary objects

The large base maps used during the interview and workshop phases of this project were integral in connecting local knowledge holders with us, the researchers, while providing a literal physical space for them to openly express and discuss their spatial wildlife knowledge and associated concerns. Using large base maps during the interviews was daunting at times, especially when interviewing participants *in situ* at their camp sites, where tables were not

always available. Although awkward to place at times, the maps between researchers and participants acted as a gateway to conversation; when participants were not comfortable looking researchers in the eyes, the maps often acted as an intermediary, allowing for the participants to explore and express their knowledge in a way their words could not fully convey.

The provision of multiple maps for each interview gave participants the agency to choose at which scale, and to which extent, they wanted to represent their knowledge based on their own lived experiences. By giving participants the ability to choose, we had these participants share their experiences with us in a way that reflected their own perceptions of the extent of the geographic region and their experiential knowledge and relational values with wildlife within it, rather than the way we as researchers may have framed them with specified boundaries. This not only prompted open discussion as to the mapped spatial data, but also enhanced wider discussions of wildlife and regional environments, encouraging participant discussion rich with nuanced and expressed values toward wildlife. The responses of participants as related to wildlife and landscape change in the region are constructed through experience with the region acting as a lens and are influenced by the physical characteristics of the region. We agree with conceptualizations such as Canter's (1991) which assert that people need to have the agency to claim their own settings, including spatial scale-related issues, rather than simply having agency within researcher-defined settings. A crucial aspect of their agency is in the active construction of their setting (Jorgensen & Stedman, 2011).

We used physical, paper maps rather than electronic, computer-based ones in our process, which proved to be both beneficial and challenging. The physical maps seemed to be well received by participants, and may have provided a more familiar experience for them as opposed to interacting digitally with a tablet or computer. The use of large, physical maps allowed for participants to thoroughly examine these maps and see the townships, topographies, geographies, indications of land cover, and other familiar landmarks, helping situate themselves within the familiar landscape. For older participants, toward which the participant sample skewed, these paper maps represented a more familiar format, and the large maps provided greater visibility than a smaller, more limited computer screen would have. These maps also provided an engaging visual element during interviews for participants to be able to focus on (as noted above), which many participants found especially delightful when

they noticed tracts of land familiar to them due to their experiences, grounding them on the map and in the region.

Some limitations to using physical base maps are the limited scales and extents a researcher must decide upon prior to the commencement of data collection; by not using digital maps where scale was adjustable, we were not able to provide maps at other scales and extents a participant may have particularly wanted or been comfortable with. A limitation identified in our study using physical base maps is that all landmarks could not be incorporated onto these maps without cluttering the maps, a limitation noted in other studies utilizing physical maps as well (e.g. Karimi et al., 2015); layers cannot be turned on and off at will to show either different land marks or land cover and usage, meaning there will always be information that some participants may find is missing that the research team did not incorporate. Lastly, some participants expressed that they were unable to read some of the smaller labels on the maps, leading to issues such as participants taking longer to situate themselves on the provided maps, at times expressing mild frustration at being unable to find a familiar landmark or road.

To address these limitations, it is important that scholars research what the important landmarks are for potential regional participants. In our study, we did not label the Old Ship Railway nor a natural gas pipeline right of way, both of which were mentioned during many interviews, with some participants explicitly telling us the maps were missing these landmarks (although the natural gas pipeline right of way was subtly evident on the maps as a linear area without vegetation). It may also be worth exploring whether imposing a cartographic grid over base maps may aid researchers, as some participants found it disconcerting to be unable to pinpoint exact locations according to grid points they knew from professional work (such as P1 and P31).

Although not necessarily a limitation, our project did not utilize the method of having participants draw their own base maps which is a method called sketch mapping, utilized to elicit information of different spatial concepts, such as routes taken within an environment, or to study people's mental conceptualizations of their environments (Boschmann & Cubbon, 2014; Wartmann & Purves, 2017). Rather, we opted to provide participants with physical base maps so as to facilitate georeferencing of base mapping layers and added spatial data across interviews, allowing for digitization of spatial data for thematic and comparative overlay analyses. A potential avenue of future research may include having participants map out from

scratch the Chignecto Isthmus, the places important to them and the wildlife that inhabit them, rather than marking on provided base maps. This could reveal further insight into how and why some spatial patterns of wildlife movement emerge when speaking with tacit knowledge holders in this region, and exactly what their frames of reference are for locating them. This could also provide an avenue for exploring how local knowledge holders value local landscapes, which is another important aspect of value elicitation in conservation and resource management research. Using maps proved effective in assisting participants with discussions of wildlife from which relational values were coded; using such maps to elicit landscape values could prove to be a natural progression in this type of work.

During interviews, participants often expressed a feeling of uncertainty when it came time to map wildlife locations and movement on the map, some expressing to us, the researchers, that this was not official scientific data but only their own observations and interpretations. This was, of course, the purpose of our study, and it was clearly explained to each participant during recruitment and prior to each individual interview. So, why did these uncertainties persist, sometimes inducing hesitancy in participant map marking? Some participants often felt they could not map something because they were unsure of the exact location and did not want to misrepresent their knowledge to the research team on their maps, although others were happy to mark-up larger, general areas; this hesitancy was not expressed by all participants and varied between individuals. I observed that a hesitancy in mapping was more likely to occur during interviews with those who had a "professional" background related to this study (i.e. retired cartographers, wildlife biologists, botanists) and thus could be linked to their previous scientific training, which may have stressed the need for precision or accuracy. Regardless, these and other hesitant individuals seemed to feel that their experiential knowledge may not "measure up" to traditional scientific data, a finding that is consistent with observations made in similar map-based studies (e.g., Warner, 2015). It could be that this hesitancy to imprecisely mark a location on a base map (which may convey a need for accuracy) may be overcome by not using a base map in the first place and instead asking the participants to draw out their perceptions from scratch. To my knowledge, this has not been tested, and may represent another question to address in future research using blank pages rather than base maps.

The hesitancy present in some interviews could prove detrimental in studies such as ours, as such hesitancy can lead to less data being provided by participants as they question the

reliability and validity of their data, resulting in less data for the research dataset, a caution noted in other studies (Warner, 2015; Spielman, 2014). In our case, through both the interviews and the workshops, we endeavored to treat participant knowledge with the same respect as more formal forms of knowledge, such as mapped outputs of computer-based models, repeatedly assuring participants we were seeking their experiential knowledge of wildlife in the region, which we recognized as valid information. In our view, requirements that local experiential knowledge be qualified as academically "valid" or "scientific" would be inappropriate. In doing so, power and agency would be taken away from the participants and, once more, thrust into the hands of the researcher who applies traditional academic systems of rigor that are not necessarily applicable in such contexts. We did not seek to have participants validate the computer models with their data, but rather used the complementary computer modelling and participant spatial data to facilitate conversations around wildlife perceptions and movement. Discrepancies between the computer models and participant spatial data provided the opportunity for conversation and knowledge co-production, without the need to "scientifically validate" the information. Further studies may work to develop respectful metrics for assessing such quality, but often such studies of metrics compare participatory mapping results to expert mapping, overlooking the other information provided, such as sociocultural context or personal histories as related to the region, as also observed by Brown and Raymond (2007). Instead, local experiential knowledge should stand side-by-side with other kinds of knowledge, providing different insights and ways of knowing, and thereby diversifying the knowledge base and making it more inclusive.

Although hesitancy in expressing their tacit, experiential knowledge was evident among some participants during their interviews, confidence emerged during the workshops, wherein there was unanimous support for the cumulative knowledge which had been displayed on the maps. There was, however, recognition that there may be some information missing, such as that on amphibians and reptiles (which was not provided by participants). These methods of knowledge co-production, between researcher and participant as well as between the participants themselves, led to a deep, nuanced picture of the Chignecto Isthmus region and its wildlife that promoted confidence in local knowledge holders and researchers alike, leading to a wealth of data that sits outside of strictly quantifiable value. The participants in this research painted the isthmus region as one filled with complex webs of interactions between wildlife,

humans, and the environment, an area that holds promise for the future of humans and wildlife alike but one that needs further conservation attention.

4.4 Research limitations

Addressing limitations is an important part of research, as it outlines the parameters within which the data sits and helps to further contextualize the research findings. Limitations were addressed in previous chapters as they pertained to the methods of analysis and the topics of those chapters. The following are the limitations identified for the thesis as an integrated body of work, and how these limitations can be addressed in future research.

There was a limited pool of participants, and the prevalent issue with the sample population are the limited demographics: only three participants were not male, and the sample skewed older-Caucasian male, or white-passing. This could be due to the demographics of the region itself, where the local, mainly rural, populations skew older and white, particularly those involved in activities such as hunting, fishing, and trapping (Hunter & Brehm, 2004). Future studies may benefit from targeting younger and non-white populations, although there may be less deep, tacit knowledge of wildlife available from younger populations due to a lack of long-term experience that comes with spending considerable time in a given area.

No participants self-identified as Indigenous, although there are Indigenous Mi'kmaw communities that have been in the region for much longer than the white, settler Canadians sampled for this study. This was a conscious, responsible "delimitation" made to avoid constraining Indigenous participants into western-centric research methodologies, effectively tokenizing Indigenous people and communities. This is important to address in any future studies, as Indigenous engagement and knowledge is essential to developing inclusive co-produced knowledge systems and for understanding the long and interconnected natural history of the land, especially on unceded territory. The long-standing relationship between Indigenous communities and the land is well-documented and needs to be included in future studies. This delimitation may be mitigated in future projects through relationship-building efforts initiated with the community prior to the research season, using guidelines developed by and for local Indigenous communities to conduct ethical research that thoroughly incorporates Indigenous ways of knowing. It is important that Indigenous rights, governance, and knowledge systems be respected and advanced in the region, including in conservation and other land-based planning and management initiatives, and therefore better ways of engaging, respecting

and including Indigenous peoples and their knowledge are warranted. If the Mi'kmaw community decides there should be this type of research conducted with their communities, it should be Indigenous-led or co-led, conducted in "ethical space" (Ermine, 2007; The Indigenous Circle of Experts, 2018), and privilege Indigenous ways of knowing or respect both Indigenous and Western systems, such as through a "two-eyed seeing" approach (Bartlett et al., 2012; Marshall, 2014). For further discussion of the ethical considerations as related to research with Indigenous communities, see Bull et al. (2019).

This research employed qualitative methodologies, namely in-depth, semi-structured interviews and workshops with subsets of the interview participants. Although these methods proved valuable in generating deep, meaningful data from our participants, these methods are time-intensive and incurred high monetary costs for travel, compensation for participants, and workshop venue and refreshments. These methods also meant we drew from a smaller sample, as limited by time and cost constraints in how many participants we could include in the research. Accordingly, our findings may not be generalized to the larger local population. This limitation may be addressed in future studies through the complementary use of quantitative mail-out or online surveys. These surveys would help mitigate the issues of time constraints (as surveys would take less time to send out and collect than conducting interviews and workshops) and would also have the potential of reaching a larger and more diverse sample of the local population. Online surveys would provide the additional opportunities for data to be captured digitally, with scrolling and zooming abilities, and the ability to change icons on base maps at will.

This was an exploratory study focused on the Chignecto Isthmus region, and thus was not meant to be generalizable beyond the study region (although some insights likely apply beyond the scope and region of this research). As it turns out, many participants were located in areas close to the border between Nova Scotia and New Brunswick, with less representation further away from the border, in other areas of the region. This could be mitigated in future studies by targeting recruitment in areas further from the border in both provinces, purposely avoiding the general location of the participant pool in this research.

4.5 Future research

The diversity of experiences present among local people with strong tacit knowledge of wildlife in the Chignecto Isthmus region is difficult to capture in one field season of data

collection, with interviews completed over the summer months (2019) and two half-day workshops held in the following January and February (2020). Further research should be done to expand the co-produced knowledge base and continue building a robust dataset for the region. One possible avenue of research could be the use of social media to track and analyze regional wildlife sightings and interaction. Social media has been harnessed to map the recreational use of and interaction with wildlife (Monkman et al., 2018), explore the impacts of poaching on wildlife (Eid & Handal, 2021), and examine perceptions and online opinions of wildlife (Fidino et al., 2018). Some of our participants already discussed using social media to share wildlife sightings with other community members, and thus these methods of digital examination could yield fascinating insights into regional human-wildlife dynamics

Some participants mentioned the possible use of aerial photographs to assist participants with orienting themselves on the maps and being able to more clearly situate their experiences in specific areas of the region. Mapedza, Wright, and Fawcett (2003) similarly recognized that some PPGIS projects may benefit from the use of aerial photography, and this could be an avenue for continuing and expanding this work. This approach may prove especially fruitful if the research is extended to include community members that are not as intimately familiar with the land and may not recognize places on a map but may recognize them on an aerial photograph.

To expand work on values, further research may entail development of an interview guide or survey explicitly aimed toward collecting and assessing participants' values toward wildlife and the environment. Using methodologies targeted toward examining values, especially as associated with participatory mapping spatial data, and/or broader mail-out or on-line surveys, may prove especially valuable in further understanding public values and contributing to regional conservation initiatives.

An avenue of research including both visual elements and human agency in expressing personal narratives associated with a landscape, or place, could be through the use of photo-elicitation paired with open-ended interviews. In their 2013 article, Sherren and Verstraten explored farmer's landscape values, especially as related to their perceptions of wetlands and climate change, by providing participating farmers with cameras and having participants take photos of parts of their farms and surrounding landscape that were significant to them. With how prominent wildlife photography, both passive and active, was in our research, the use of

photo-elicitation to aid in the discussion of human-wildlife interaction narratives could be prove interesting and fruitful.

Another avenue of exploratory, non-directive research might include having participants draw their own maps of the region, or reflect upon their experiences through other methods, such as through writing their own narratives, visually illustrating their experiences or acting them out. My research melded some forms of involvement together for data collection purposes, but there are other creative social science methods that may be effective in seeking conservation-oriented research engagement. This can include the collection of qualitative data on values, such as using audiovisual capture methods (Van Der Linde & Mans, 2015) or a variety of creative art expressions (Lopez et al., 2018), alongside spatial data.

4.6 Conclusions

Our research strove to examine and present the experiences of local tacit knowledge holders of the Chignecto Isthmus with regional wildlife, adding this important contribution to the knowledge base surrounding wildlife in the region. A total of 34 local tacit knowledge holders, with experiential knowledge of wildlife and the landscapes of the Chignecto Isthmus, were interviewed. Two subsequent workshops in which a subset of the participants engaged proved to be effective spaces for co-producing wildlife movement, distribution, population, and mortality knowledge. There are multiple experiences that cannot be captured in one study, especially across stakeholder groups, as demonstrated by the diverse and overlapping relational wildlife values, wildlife-human interactions, and how personal narratives are intertwined with change in the region. Participants identified that there are many factors affecting the abundance, distribution, and movement of wildlife in the region, and the concerns about wildlife and the changes in those populations are further exacerbated both by the imminence of climate change impacts and the expansion of forestry, roads and other land altering developments.

Not only was valuable data collected, but the stakeholders involved expressed interest and a renewed way of looking at wildlife, such as their tracks and other observations within the region and questioning what they mean. This interest is useful and necessary for current and future planning and management considerations in the region, whether these be related to transportation and other infrastructure, climate change mitigation, or biodiversity conservation.

Participants expressed myriad relational values toward wildlife, connecting with wildlife through *Naturalistic* and Utilitarian encounters, through *Ecologistic-Scientific or Reasoning* appreciation of wildlife's place, or sometimes through the *Symbolic* meanings wildlife had in their lives. The subtheme of connecting with wildlife over *Naturalistic* or *Aesthetic* values in contrast to *Utilitarian* ones, displaying a transition from hunting with a gun to photo-hunting, may prove to be an interesting future line of research or those seeking to understand how alternative methods of human-wildlife relationship can be encouraged for greater conservation buy-in. Photography is a powerful visual method of connection with wildlife and may also serve to connect people in their shared interest and admiration of wildlife across different temporal and geographic scales.

This research shows that using social science methodologies toward mutual goals of conserving and protecting the biodiversity that remains is both possible and necessary, contributing as part of the collective of environmental research calling for the use of social science methodologies in conservation research and initiatives for effective and inclusive co-produced systems of knowledge (e.g. Bennett et al., 2017; Greg Brown & Kyttä, 2018; K. Brown et al., 2019; Endter-Wada, Blahna, Krannich, & Brunson, 1998; Redpath et al., 2013; Waylen et al., 2010). The knowledge shared throughout this study serves to illustrate the complexities in the region and the systemic changes occurring that are affecting humans, wildlife and their relationships, illuminating issues that were addressed in previous studies of the region with tacit knowledge holders of the region (Macdonald & Clowater, 2005). The collaboration between academic researchers, scientific experts, and local knowledge holders resulted in cohesive maps with spatial information that complemented and overlapped, enriched by the qualitative findings. The findings from this research will help further contextualize the human-wildlife and wildlife-spatial relationships, providing perspectives surrounding wildlife imbued with relational values and evidence for the long-held scientific beliefs of what is impacting wildlife in the region, namely habitat loss, habitat fragmentation, and road mortality (Macdonald & Clowater, 2005; Nussey & Noseworthy, 2018).

Landscape connectivity, which is desperately needed to facilitate wildlife movement and the gene flow necessary to maintain diverse wildlife species, is dependent on the wider social acceptance of coexistence, or at the very least tolerance, between humans and wildlife, as well as buy-in into private and public land conservation initiatives. Effective initiatives require

engagement and communication with local stakeholders in the development of community plans using mixed methods of top-down and bottom-up approaches (Redpath et al., 2013). Integration between expert and local knowledge through social science methodologies is integral to the success of biodiversity conservation initiatives (Chan et al., 2007) and this research has served to show that there is a strong base of tacit knowledge within the Chignecto Isthmus region that can support future studies looking to incorporate social science methodologies to strengthen their results. Local knowledge holders have valuable land-based knowledge to share that reflects their emotional sociocultural, naturalistic, and ecologistic histories, which enrich data on wildlife populations, movement, distribution, and declines. This complex co-generated knowledge provides an avenue for connecting people to conservation initiatives through their attachments to wildlife. Mobilizing knowledge is important not only for conservation initiatives at a local scale but also for a wider, big-picture understanding of the issues faced by wildlife in key areas of connectivity. Humans have a powerful influence on the landscape, no matter where they are geographically located, and it is inevitable that the fate of Canadian wildlife be linked with human actions. Just as human actions and values toward wildlife are complex and have been puzzled over by academics and practitioners for decades. So too are the approaches to conservation and coexisting with wildlife and ensuring nature-human coupled systems thrive as we head into an uncertain future.

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APPENDIX A Interview Guide

Interview (1-2 hours)

The research assistant and field assistant will introduce themselves and thank the participant for meeting them for an interview.

The interviewers will give the participant time to settle in, offering a few minutes if meeting at a coffee shop or other space offering refreshments for the participant to make any purchase and feel comfortable. Once both interviewers and interviewee are settled in, the researchers will re-summarize the study and data collection methods, review the informed consent form, answer any questions, and seek consent, obtained by signing the consent form. With the participant's permission, the audio recording device will then be switched on.

Key questions for the semi-structured interview are provided in the template, below. These questions are meant as prompts to be used if the topics do not naturally arise in conversation. They will not necessarily be asked in any order in particular or asked at all if the participant leads the conversation toward the topic(s) themselves. The base maps will be displayed between participant and researchers (if there is a table or other object; if not, the researcher will invite the participant to look at the maps before beginning the interview and proceed to either hold the maps or allow the participant to hold the maps for the duration of the interview portion, depending on participant preference). The researcher will use the base study maps of the Chignecto Isthmus region to help the participant visualize the region(s) being spoken of during the interview by pointing to regions identified by the participant and asking questions, if deemed necessary or beneficial by the researcher.

Before launching into core topics pertinent to the study, contextual and rapport-building questions will be asked. The researchers will ask the participant about themselves, such as where the participant lives, how they came to live in the area, how long they have lived there, where they have traveled to within the region, and in which kinds of activities they participate on the land (Topic 1). Researchers will keep track of which of the topic areas and questions arise and are addressed naturally, and then prompt around those not yet addressed prior to ending the interview. Researchers should use the following template to keep track of what is addressed, and to make any other relevant notations, such as key words or phrases, observations or interpretations, clarifications needed, etc.

The conversation, questioning and participatory mapping will take place together, with notations being made on the map as spatially relevant topics arise.

To begin: *Just to be clear, there are no right or wrong answers to any of my questions. I am looking to understand your experience and views. If there is any question you don't want to answer, that is OK, just let me know and we can move on….*

Topic 1: Time and types of experience in the Chignecto Isthmus region	
Pointing to the map: *Let's begin by speaking about which area would you refer to as being the Chignecto isthmus and your experiences in this region.* • How far does it extend, based on your own personal experience? What parts of this region are you familiar with? Most familiar with? How do you spend your time on the land in the Chignecto Isthmus region? • How often do you find yourself spending time out on the land, in nature, in the Chignecto Isthmus region? • Are there specific seasons during which you spend more or less time out on the land? If so, what are they and why? **If participant indicates they live in the area**: Have you always lived in the region/ how long have you lived here? How did you come to live in the area? **If participant indicates they do not live in the area**: What prompts you to travel to this region specifically? Where do you usually travel to in the region? How often, and for how long? How long have you been doing this? **For all:** Where have you traveled [how extensively] within the region? What kinds of activities do you do out on the land? [hunt, fish, trap, hike, snowmobile, etc]. Tell me more about these activities; would you say these activities are more of a necessity or more recreational [more fun] for you?	

• How long have you been participating in these activities? Do you participate in them often? • Do you tend to participate in these activities individually or in a group?	
Topic 2: Participatory mapping Note: Mapping is not to be conceived as a separate topic or portion of the interview, but rather as an integral part of the interview, as a means of recording their responses in a spatial and geo-referenced way.	
Let's take another look at the maps we have brought. One is larger, showing the entire region. The second one focuses on the border area between Nova Scotia and New Brunswick. Which map or maps would you feel most comfortable using to talk about where you see wildlife? …Is there a reason you are most comfortable with the chosen map(s)? *I'd like you to draw on the maps areas where you have seen various species of wildlife. You can use whichever colours you like.* *As you are making these markings on the map(s), I would like you to speak your thoughts out loud so we can understand what you are showing us.* *There are no right or wrong answers, we are interested in seeing your experiences visualized on this/these map(s).* Where you have seen various species of wildlife? Which species? (Wildlife includes animals, birds, fish, etc.) Are there particular areas where you see wildlife moving, from place to place? Where are they? Which species? • Are there wildlife movement 'pathways' or trails that you are aware of? *We are interested in hearing about any wildlife you have seen or interacted with in the region, but we also have an interest in specific species that live in the region.* Do you ever see … (name the 12 species for which NCC modeled movement corridors)? Where?	

Do you think there is more wildlife present in these areas that you have marked than in other areas? Why/why not?	
Topic 3: Wildlife in the Chignecto Isthmus Region [There is overlap among these topics and those addressed in the mapping. Responses will be noted spatially/geographically on the map, and other relevant responses will be noted here.]	
While spending time in the region, have you come across many species of wildlife? What species have you noticed the most during your time spent in this/these region(s)? • Are there some species that stand out or are more important to you than others? Why? In which areas do you most often notice these species, or the lack of them? • Have you noticed the same species in multiple areas of the Chignecto Isthmus? Where? • Why do you think you notice these species? (Do you think this has anything to do with the activity you participate in)?	
Over the time you have spent in this region, have you noticed any difference in how often or how much of this species you've seen? Are there any thoughts you have as to why there might be these differences? During your time in this/these region(s), have you noticed any wildlife mortality (death)? • Do you notice this dead wildlife in any specific areas you have come across? Are there areas where you have noticed more of this dead wildlife? • Where have you noticed dead wildlife, such as road kill? Are there areas where you see more roadkill? What species? Are there particular times of year when you see more roadkill?	

Topic 4: Conversations around conservation [and wildlife-road mitigation]	
I'd like to move the conversation now to ideas around conserving wildlife. Can you think of/Do you think there are any specific things that are happening in this region that may be interfering with the ability of wildlife individuals to thrive? • What about the ability to support healthy populations of wildlife? What things might be contributing to the death or injury of wildlife, not including hunting, trapping, fishing, etc? Have you noticed injured or dead wildlife on or around roads in the regions? Where? Which species? Have you noticed any species avoiding roads (e.g., coming up to a road but then moving away)? • Or not being able to get across roads or other barriers (e.g., fish at roads, culverts, dams, etc; wildlife at fences)? • Are there [specific] areas where you think animals (including fish) would like to move but can't, or where it is harder for them to move because of human activities or developments? What about roads? Dams? Can you think of any strategies for reducing the death of wildlife on or around roads? • Any ideas for how to make roads safer for wildlife passage (and people)? [Researcher may prompt by speaking about the idea of underpasses and overpasses, as an example, if there is confusion/hesitation when referring to strategies] Do you think the reduction of wildlife injury and death due to vehicle collisions would be beneficial to you and others who use this region? • Why or why not?	

Topic 5: **Other/conclusion** *Is there anything else we did not cover that you'd like to share or elaborate on?*	

The participatory mapping will conclude when the participant makes it clear that they are finished plotting data onto the provided map(s). The concluding discussion between researcher and participant will include speaking about how the participant felt about the experience and if they were comfortable marking on the provided map(s).

The researcher will ask if they have any final questions or concerns.

The research assistant will reiterate that the participant may contact them or Dr. Karen Beazley at any point with any questions or concerns through the provided contact information in the consent form.

At the conclusion of the interview (or when the participant chooses to end the session) the participant will be given a $25 gas or grocery card (their choice) as a token of appreciation for their time.

APPENDIX B Materials and table for elicitation of prompted/unprompted species data collection

Wildlife Species

Moose

Black Bear

Red Fox

Bobcat

Snowshoe hare

Fisher

Northern Flying Squirrel

Northern Goshawk

Pileated Woodpecker

Brown Creeper

Boreal Chickadee

Blackburnian Warbler

Note List of species, as modelled in Nussey (2016), provided to participants during interviews to prompt further discussion

Table B1 Prompted and unprompted species using wildlife modelled in Nussey (2016)

Species	Unprompted	Prompted
Moose **tia'm** (*Alces alces americanus*)	32	2
Snowshoe hare[a] **apli'kmuj** (*Lepus americanus)*	3	9
Northern flying squirrel **sasqatu** (*Glaucomys sabrinus*)	1	17
Fisher **êpkwamk** (*Martes pennanti*)	8	10
Red fox **wiskoksit** (*Vulpes vulpes*)	6	10
Bobcat **Tqoqwej** (*Lynx rufus*)	12	4
Black bear **muin** (*Ursus americanus*)	23	7
Pileated woodpecker **han'tawesk** (*Dryocopus pileatus)*	1	15
Brown creeper (*Certhia americana*)	0	6
Boreal chickadee **bièlchìj (k)** (*Poecile hudsonicus*)	1	5
Blackburnian warbler **Gedabegiejijik** (*Setophaga fusca*)	0	8
Northern goshawk **Beehooguess** (*Accipiter gentilis*)	4	11

Note. Unprompted species were freely brought up and discussed by participants prior to presentation of Nussey's (2016) list of species, while prompted species were discussed after presentation of the list during an interview.

Mi'kmaq names are bolded and binomial scientific names are in brackets. Mi'kmaq names sourced from Hebda (2014).

[a]Snowshoe hare numbers contain combined numbers of instances coded under both “Snowshoe hare” and “Hare”, as some participants did not explicitly identify “Snowshoe Hare” during interviews but a more generic “Hare”. There is only one species of hare that lives in NS and NB.