



Research

Impacts of harvested species declines on Indigenous Peoples' food sovereignty, well-being and ways of life: a case study of Anishinaabe perspectives and moose

Pauline Priadka¹ , Brittany Moses², Cory Kozmik³, Steven Kell⁴ and Jesse N. Popp¹

ABSTRACT. Global declines in wildlife are increasing the vulnerability of Indigenous communities to food insecurity. Meanwhile, many colonial policies continue to ignore social-ecological relationships that have traditionally maintained a balance between wildlife and Indigenous Peoples' subsistence needs. We provide a case study on perspectives and insights from three Anishinaabe Nations in Ontario, Canada on the importance of a traditional food, moose (*mooz* [Nishnaabemowin]; *Alces alces*), and how changes in the moose population are affecting food security, well-being, and ways of life. In partnership with each Nation, we conducted interviews with community members and related observations on change in the moose population to estimates of moose abundance and non-Indigenous harvest collected by the Ontario provincial government over a 16-year time frame (2001–2016). Moose was described as important for subsistence needs as well as for maintaining Anishinabek culture, traditions, and identity within each community. A decline in the moose population was observed by most participants, which corresponded with provincial data on moose abundance. Additionally, the number of non-Indigenous hunters per moose harvested on traditional territories increased linearly over time, and community members expressed concern over how the province was managing moose. The effects of moose decline in the communities included reduced food security and health, increased financial costs due to both relying more on store-bought foods and having to travel further to harvest moose, as well as a decline in the practice of traditions and ceremonies surrounding moose harvest and passing this knowledge on to younger generations. Despite the potential impacts on Indigenous subsistence harvest, there is a lack of collaborative decision-making with Indigenous communities on moose population and harvest management in Ontario. Using community perspectives and insights, we discuss how autonomous moose monitoring can support and facilitate co-management and collaborative decision-making to reinstate Indigenous food sovereignty.

Key Words: *co-management; food security; Indigenous knowledge; reconciliation; traditional food; traditional knowledge; wildlife harvesting; wildlife management*

POSITIONALITY STATEMENT

First and foremost, the author team would like to say *chi-miigwetch* (thank you very much) to all of the Elders and knowledge holders from Biigtigong Nishnaabeg, Magnetawan First Nation, and Shawanaga First Nation who shared their knowledge and insights on *mooz* (moose) for this project. The author team carries great responsibility to share this knowledge and elevate Indigenous voices while standing with Indigenous Peoples to advocate for diversity, inclusivity, and transformation in the natural sciences and environmental management. The author team is a diverse team consisting of two Anishinaabekwe (Anishinabek women; Wiikwemkoong Unceded Territory and Biigtigong Nishnaabeg), three representatives from the lands departments of partner First Nations (one representative from each), and one non-Indigenous ally. Each author has spent many years, if not a lifetime, working with communities in the Anishinabek Nation.

INTRODUCTION

As global trends in fish and wildlife populations continue to decline, vulnerability to food insecurity is exacerbated across many Indigenous communities that rely on fish and wildlife as traditional foods (Elliott et al. 2012, Lam et al. 2019, Little et al. 2021). In Canada, off-reserve First Nation households are nearly four times more likely to be food insecure than non-Indigenous households (Willows et al. 2009). Chronic diseases such as

diabetes are more prevalent in Indigenous Peoples due to diet that has shifted away from traditional foods (Young et al. 2000, Damman et al. 2008, Hackett et al. 2021). Although food insecurity for Indigenous Peoples is a cumulative result of factors that also include a rapid change in lifestyle and often restricted access to healthy foods, many communities experience limited capacity and sovereignty over access and management of traditional foods that have sustained communities for millennia (Hackett et al. 2021, Little et al. 2021). As challenges relating to levels of food security and access to healthy foods persist, there is growing recognition of the importance of discourse and developing decolonized food and wildlife policies that recognize contemporary Indigenous reliance on traditional foods (Rudolph and McLachlan 2013, Desmarais and Wittman 2014, Grey and Patel 2015, Coté 2016).

While Indigenous Peoples have historically relied on many fish and wildlife species for subsistence, traditional foods also hold cultural and spiritual importance that contribute to well-being and maintaining ways of life (Berkes 2009b, Tobias and Richmond 2014). Ways of life can include the practice of traditions and ceremonies that are tied to the community and environment; in many Indigenous worldviews, well-being encompasses physical, social, spiritual, and mental health (Isaak and Marchessault 2008, Tobias and Richmond 2014). Wildlife harvesting, for example, is a physical and spiritual practice that is part of a traditional way

¹School of Environmental Sciences, University of Guelph, ²Sustainable Development Department, Biigtigong Nishnaabeg, ³Lands, Resources and Environment Department, Magnetawan First Nation, ⁴Lands and Resource Department, Shawanaga First Nation

of life and involves traditional ceremonies and reciprocity through providing and sharing food and knowledge within families and communities. Wildlife harvesting is also recognized as a source of post-colonial healing that helps individuals to reconnect with their heritage, culture, identity, spirituality, and environment while supporting individual and community well-being (Marquina-Márquez et al. 2016). Continual losses of fish and wildlife due to environmental change have negative impacts on Indigenous Peoples through declines in well-being and ways of life, in addition to food insecurity at community levels (Turner and Spalding 2013, Tobias and Richmond 2014, Whitney et al. 2020).

In the shadow of colonialism and systemic racism, many current decision-making processes in environmental management have not yet evolved to address the needs and perspectives of Indigenous Peoples, despite Indigenous communities often being the most affected by changes to the environment (Elliott et al. 2012). Although most Indigenous Peoples have historically been able to adapt to environmental change, the impacts of post-colonialization Indigenous dispossession from traditional territories are being realized globally as communities struggle to maintain social-ecological relationships and food insecurity increases (Tobias and Richmond 2014, Salomon et al. 2019, Whitney et al. 2020). As a step toward reconciliation, initiatives are emerging globally that support ways for Indigenous Peoples to be reconnected to the land. For example, Canada has launched a multiyear Indigenous Guardians Pilot Program that supports Indigenous-led monitoring and guardianship (i.e., stewardship) of the environment (Reed et al. 2020). However, despite efforts to reconnect Indigenous Peoples with traditional lands and contribute to reconciling Indigenous dispossession, the capacity for Indigenous self-governance and the ability to respond to environmental changes are often still limited (Artelle et al. 2019, Fournier et al. 2019).

Indigenous self-governance can reinstate food sovereignty and enable resilience to environmental changes in communities to support ways of life and holistic well-being (Socha et al. 2012, Huntington et al. 2019). The food sovereignty concept recognizes people's rights to access and hold decision-making power over healthy foods that promote individual and community-level well-being while supporting social-ecological capacity to adapt to environmental changes (Grey and Patel 2015, Lam et al. 2019, Salomon et al. 2019). Although examples are still emerging, moves toward food sovereignty can be supported by co-management of the environment at local community scales (Cruickshank et al. 2019, Popp et al. 2019). Environmental co-management includes knowledge co-production and multiple ways of knowing, as well as sharing of power and responsibility (Berkes 2009a), and has been documented to provide holistic approaches that strengthen environmental policy while reinstating Indigenous Peoples' relationships with the land (Spak 2005, Armitage et al. 2011, Popp et al. 2019). Co-management has also helped to address food security by bridging gaps between Indigenous well-being and access to traditional foods while providing capacity for social-ecological resilience (McConney et al. 2015, Cruickshank et al. 2019, Popp et al. 2019). As part of a larger discussion surrounding reconciliation, the inclusion of Indigenous knowledge systems, values, and ways of life in environmental and wildlife policy remains an ongoing dialogue between nation-state governments

and Indigenous Nations globally, particularly as environmental change continues to contribute to wildlife declines and exacerbate food insecurity (Elliott et al. 2012, Huntington et al. 2019, Salomon et al. 2019).

Using a case study of Anishinaabe perspectives on moose (*moos* [Nishnaabemowin]; *Alces alces*) in Ontario, Canada, we document an example of how declines in a traditional food is affecting Indigenous well-being and ways of life and examine how the capacity for communities to respond and adapt to environmental change can be improved to reinstate food sovereignty. This research project was initiated and conducted in partnership with Biigtigong Nishnaabeg, an Anishinaabe Nation that had expressed concern over the state of the moose population and its impacts on Anishinaabe well-being and ways of life. It was then expanded to include the perspectives of two other neighboring Anishinaabe Nations that also rely heavily on moose to meet subsistence needs and had expressed concerns over moose declines: Magnetawan First Nation and Shawanaga First Nation.

Moose is a herbivorous large mammal found in the Nearctic boreal forest and has been harvested by Indigenous Peoples in Canada since time immemorial (LeBlanc et al. 2012). The species holds cultural and spiritual importance to the Anishinaabe and continues to be an important part of the diet as a traditional and subsistence food (Popp et al. 2019). In Canada, Indigenous People have a right to harvest wildlife to meet their subsistence needs without provincial or federal restrictions or regulations. However, many Indigenous communities do enforce community-specific laws that govern how resources are used on traditional territories. Moose are also harvested by non-Indigenous residents in Canada for subsistence and recreational use. Local and regional declines of the species across its distribution in both Canada and USA (Timmermann and Rodgers 2017) have put pressure on jurisdictional management to ensure sustainable harvests, particularly as the potential for mismanagement increases. Causes of moose declines in North America are linked to climate change and habitat loss, which contribute to changes in ecosystems and interspecific interactions that increase the prevalence of parasites, pathogens, and risks of predation and over-harvest (Ranta and Lankester 2017, Timmermann and Rodgers 2017). In Ontario, the moose population has experienced a downward trend since the early 2000s at the provincial scale (Timmermann and Rodgers 2017). Moose management in Ontario is governed by the provincial Ministry of Natural Resources and Forestry (MNRF), and to date, the province does not directly engage with First Nations on moose population or harvest management.

We document perspectives and insights from the three Anishinaabe Nations in Ontario on: (1) the importance of moose and moose harvest to each community, (2) observed changes in the moose population, (3) how changes in the moose population are affecting community members' ways of life and well-being, and (4) whether there is community-level support for autonomous moose population and harvest monitoring to facilitate co-management. We compared Anishinaabe observations on changes in the moose population with estimates of moose abundance and non-Indigenous harvest indices collected by the Ontario MNRF over a 16-year time frame (2001–2016). Lastly, we used Anishinaabe perspectives to discuss how autonomous moose monitoring and co-management can help to reinstate

Indigenous rights and food sovereignty. Our findings are intended to inform wildlife policy and highlight the need for collaborative decision-making that accounts for the ways of life and well-being of Indigenous Peoples while progressing toward reconciliation.

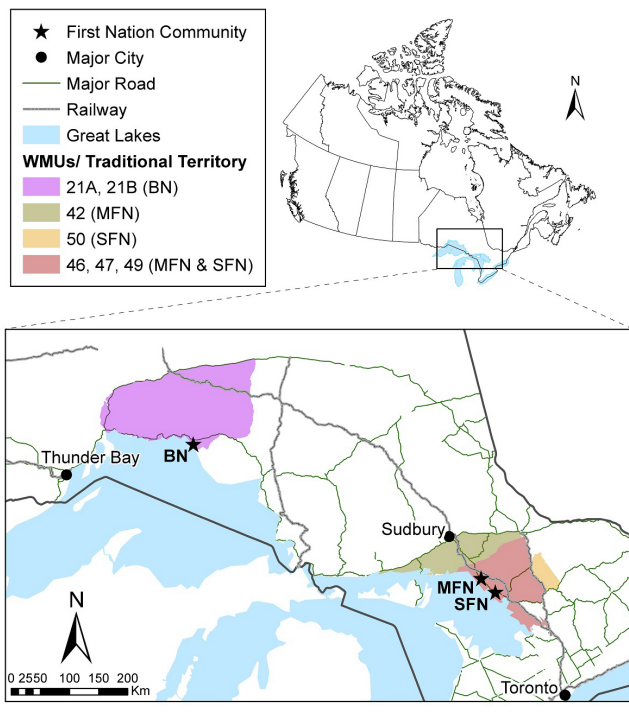
METHODS

Study area

The three Anishinaabe communities that participated in this study are located along the northern coast of the Great Lakes in Ontario, Canada (Fig. 1). According to Statistics Canada's 2016 census, the number of on-reserve registered (i.e., status) Indigenous members in each community included 415 people in Biigtigong Nishnaabeg, 90 people in Magnetawan First Nation, and 175 people in Shawanaga First Nation. Each community is connected to each other community and a major city (> 100,000 people) by a major road. Thunder Bay is the nearest major city to Biigtigong Nishnaabeg (~310 km); Sudbury is the closest major city to Magnetawan First Nation (~100 km) and Shawanaga First Nation (~135 km). In addition to roads (including forestry roads), the landscape is fragmented by railways that cut through the traditional territories of each community (Fig. 1).

The majority of the landscape in the Great Lakes region in Ontario comprises continuous boreal forest and Great Lakes–St. Lawrence forest, which support a biodiverse boreal ecosystem with large mammals, including moose, white-tailed deer

Fig. 1. Map of the study area, outlining each Anishinaabe Nation community that participated in the study, including Biigtigong Nishnaabeg (BN), Magnetawan First Nation (MFN), and Shawanaga First Nation (SFN) and approximate traditional territory based on overlapping Wildlife Management Units (WMUs) in Ontario, Canada.



(*waawaashkeshi*; *Odocoileus virginianus*), boreal woodland caribou (*adik*; *Rangifer tarandus caribou*), elk (*mashkoozh*; *Cervus canadensis*), and their predators, including wolves (*mahiinganhs*; *Canis lupus*), coyotes (*mahiinganhs*; *Canis latrans*), and black bears (*makwa*; *Ursus americanus*).

Interviews

We conducted semi-structured interviews in each community to document perspectives and knowledge about the status of and concerns about the local moose population on traditional territories and to gauge support for autonomous moose monitoring. Pre-determined questions were constructed by an Anishinaabe coauthor following initial discussions with Biigtigong Nishnaabeg's Chief, who expressed concerns over moose declines and the need for a moose monitoring and management system in the community. Interview questions were designed to be accessible to people with different perspectives and experience levels with moose, and most questions were open-ended to invite any concerns or insights to be shared by participants. All members of the community were invited to participate in interviews, including men and women, as well as youths, adults, and Elders, and we did not attempt to sample certain experience levels (e.g., hunters only). All participants were treated equally as knowledge holders.

Interviews at Biigtigong Nishnaabeg took place in July 2017 during the community's pow wow and in October 2017 during the community's annual moose hunt camp. These interviews were completed by academic researchers, including those from Laurentian University, who were involved in the study. Interviews were then extended to include community members from Magnetawan First Nation, which took place between June and July 2018, and Shawanaga First Nation, which took place between August and October 2019. These interviews were completed by academic researchers (for Magnetawan First Nation) and by the band office staff (for Shawanaga First Nation) and included the same set of pre-determined questions. Interview lengths varied from 15 to 45 min. All communities approved participating in the study, and ethics approval was received from Laurentian University prior to conducting interviews. All participants read and signed consent forms prior to interviews that permitted the interview to be audio-recorded and used to complete reports and collaborative studies such as this one.

Interview audio recordings were transcribed using Trint software (<https://trint.com/>, London, UK). Qualitative data were initially evaluated separately for each community, and then information was compared among communities to identify similarities or nuances. Responses were organized by question and manually categorized in Microsoft Excel to identify common or reoccurring themes in open-ended responses (Appendix 1). Responses were additionally categorized based on yes/no/unsure responses or by the number of mentions. Direct quotes were used as often as possible to prevent the misrepresentation of information shared. The names of participants to whom direct quotations belonged were included if they had granted permission to be named; otherwise individuals were indicated as anonymous.

Interview results validation and sharing with communities occurred in multiple steps. First, results from interviews were presented as reports titled *Anishinaabe Knowledge and Perspectives on Moose* that were provided to each community.

Reports were then distributed by the band office to participants and included feedback forms for written responses. A results-sharing session was then held virtually for each community in January 2021, and all community members (including interview participants) were invited to attend. The opportunity for verbal feedback on results was also provided during a live question period at the end of each results-sharing session. Sessions were coordinated with help from the band office, including set-up and advertising in the communities. Both verbal and written feedback received from the participating communities were used to guide the objectives and questions of interest that were included in this study. Where appropriate, information from interviews was pooled among communities to represent Anishinaabe traditions, values, and perspectives. Additionally, nuances in information shared were outlined to reflect community-specific insights and concerns.

Moose growth rates

To identify similarities and differences among Anishinaabe knowledge and observations of moose population changes and monitoring data, we assessed population density and rates of change in estimates of moose abundance and non-Indigenous harvest indices collected by the Ontario MNRF over a 16-year time frame (2001–2016). Records of projected moose density and abundance, as well as non-Indigenous harvest and number of hunters, were obtained from the Ontario MNRF. The main method of monitoring moose in Ontario is by aerial survey, which is conducted using a stratified random sampling approach of plots within Wildlife Management Units (WMUs). WMUs are surveyed approximately every three to five years by the MNRF. Harvest statistics on non-Indigenous harvest, including number of moose harvested and number of moose hunters, is collected annually for each WMU by the MNRF through mail-in and online questionnaires sent to non-Indigenous hunters following the moose hunting season. During the study period, hunter response to questionnaires was voluntary, and response rates were on average 68% for all WMUs included in the study. Non-Indigenous moose harvest in Ontario is managed by a selective harvest system that permits greater harvest of moose bulls than cows and calves (Priadka et al. 2020). Non-Indigenous hunters wishing to hunt moose are required to apply to a draw for a moose bull or cow tag, and up to 15 hunters are permitted to hunt as a group with one moose tag. Non-Indigenous hunters were also able to purchase a calf tag during the study period without applying to a draw. Moose tags are valid only within the WMU in which they are issued and during the moose hunting season that occurs between mid-September to mid-December each year. The number of tag allocations and hunters permitted in a WMU is managed by the MNRF without direct consultation with First Nation communities. In Ontario, Indigenous harvest is recognized as an inherent right, and Indigenous hunters are not required to purchase a hunting license or a tag to harvest an animal. Information on Indigenous harvest success is not collected by the MNRF. During the time that interviews were conducted, no First Nations community that participated in the study was conducting community-based monitoring of the moose population or harvest.

We assigned WMUs to each First Nation in the study that most closely overlapped with each community's traditional territory. If traditional territory boundaries were not known, we included

areas where community members indicated hunting moose. WMUs 21A and 21B were assigned to Biigtigong Nishnaabeg, WMU 42 was assigned to Magnetawan First Nation, and WMU 50 was assigned to Shawanaga First Nation (Fig. 1). WMUs 46, 47, and 49 contained overlapping traditional territories and were assigned to both Magnetawan and Shawanaga First Nation (Fig. 1). Moose population data for WMUs 47 and 49 were based on amalgamated aerial surveys that took place since 2005.

Growth rate (*GR*) for both moose abundance and non-Indigenous harvest over a 16-year period from 2001 to 2016 was calculated as:

$$GR_{WMU} = \frac{LN(N_{2016} / N_{2001})}{\text{years between surveys}} \quad (1)$$

where *N* was either projected moose abundance or projected harvest. Values of *N* were natural log-transformed (LN) to calculate an instantaneous rate of change per year. Because moose surveys in Ontario do not occur annually at the WMU level, we used the closest available survey to years 2001 and 2016 for each WMU. Growth rates were calculated for each WMU and then averaged across WMUs for each community to obtain an intrinsic growth rate for moose abundance and non-Indigenous harvest within each traditional territory (*TT*):

$$GR_{TT} = \frac{\sum_{i=1}^n GR_{WMU_1} + GR_{WMU_2} + \dots + GR_{WMU_n}}{\text{number of WMU in TT}} \quad (2)$$

We additionally evaluated the change in the number of non-Indigenous moose hunters per moose harvested from 2001 to 2016. The number of hunters was divided by the number of moose harvested in each WMU and year, which was averaged across WMUs in each traditional territory to obtain a rate of hunters per harvest in the traditional territory of each community. All plots were prepared using R (R Core Team 2020) package *ggplot2* (Wickham 2016).

RESULTS

Interviews

The number of community members that participated in interviews in each community varied from 15 to 34 individuals, with a total of 66 participants (Table 1). Both men and women participated from each community, and all participants except one youth were adults (≥ 21 years old). Not every participant identified themselves as a moose hunter, but most participants indicated that they consumed moose at least once or twice a year (Table 1).

Moose importance

Moose were described as both an important part of the surrounding environment and as “one of our main staples of food” (Anonymous, Shawanaga First Nation). Additionally, the roles that moose have in providing health and social benefits while embodying Anishinaabe culture and identity were emphasized by most participants from all three communities.

It's part of our main heritage of who we are as the Anishinabek. – Sharon Desmoulin, Biigtigong Nishnaabeg

Table 1. Summary information on the participants from three Anishinaabe Nation communities that took part in interviews.

Community	Male participants (N)	Female participants (N)	Total participants (N)	Participants who hunt moose (%)	Participants who eat moose (%)
Biigtigong Nishnaabeg	13	21	34	59	91
Magnetawan First Nation	8	7	15	60	87
Shawanaga First Nation	10	7	17	29	94

That's part of who we are. That's part of our community, like part of our lifestyle, moose. We take a lot of pride in the moose. – Anonymous, Magnetawan First Nation

Participants from all three communities attributed moose with family and community gatherings. The link to family was particularly emphasized by community members of Biigtigong Nishnaabeg, which holds an annual moose hunt camp where families from the community gather to hunt moose and participate in the processing of harvested moose following the hunt. This time of gathering was also described as an integral time to perform ceremonies and for the transfer of knowledge, teachings, and ceremonial practices to individuals in the community, especially the younger generation.

[Moose is] important because it's a way of gathering. It's a way of coming together and spending time with community members, learning different traditions and techniques. – Raven Courchene, Biigtigong Nishnaabeg

It's more than food, it's creating this whole circle of being so you're getting the teaching aspects, you're getting the social aspect [...] The value of a moose is far greater than one person thinks [...] just one moose alone could feed an entire family [...] but it also feeds the value of the family for teachings as well. And intergenerational transmission of knowledge. – Juanita Starr, Biigtigong Nishnaabeg

Moose meat was described as both a medicine and a delicacy, and its importance to the well-being of Indigenous People as a healthy food was emphasized.

Moose are one of the animals that feed off the vegetation in our area. They are the ones that gather that medicine and it becomes a part of them, so that when we are unable to get to our medicines, when we partake in moose, we receive their medicines that they've already taken. – Roger Jacklin, Magnetawan First Nation

Moose meat was shared among family members and members of the community that could not hunt for themselves. This practice of sharing and reciprocity associated with the harvest was emphasized in all three communities.

Moose are important to me and my family. It's source of food for us [...]. We will hunt our moose and when we get our moose, we actually just take what we need, enough for the winter, and we will go and we just give it to the rest of the community, the Elders in the community, and

anybody else that needs moose. We've always done that for the longest time. – Jeremy Michano, Biigtigong Nishnaabeg

In addition to being an integral source of food that brings families and the community together, all aspects of the moose were described as being used and shared, including parts of moose that are used to make art, ceremonial items, and traditional articles of clothing representing the Anishinaabe culture.

Moose they keep us fed for the winter. Also, we use the hides for different things in our culture. We can tan the hides and make it into leather. Use the moose leather for moccasins, gloves, anything, anything you name. Can use leather for and then you can also dry the hide and use it for our drums. Hand drums, big drums. Rattles, anything like that. But yeah. Most importantly it brings food to our community, to our people. Helps a lot. For our community. – Isaac Hanson, Biigtigong Nishnaabeg

Many participants also emphasized that having access to moose meat was important in offsetting food-related costs for families. However, reliance on moose meat varied across participants, with some people relying heavily on moose to feed their families, and others rarely having access to it. One member of Shawanaga First Nation indicated that moose contributed to approximately 1–2% of their diet, while another participant shared:

We harvest one [moose] a year usually to help offset the cost of food. I have [...] a large family [...] so helping to save money by harvesting moose [...] is big savings for me. We'll save probably seven–eight hundred dollars when we harvest a moose, at least. – Jerry Smith, Magnetawan First Nation

Observed changes in the moose population

Most participants (> 60% in each community) indicated observing a decline in moose numbers over an approximately 20-year time frame in the traditional territory, whereas some people indicated observing no change (average 20% of participants across communities) or an increase in moose numbers (average 3% of participants across communities; Table 2). The greatest decline in moose was observed by participants in Magnetawan First Nation, followed by Shawanaga First Nation and Biigtigong Nishnaabeg (Table 2). A decline in both the number of adult moose as well as calves was mentioned.

Table 2. Proportions of community members ($N = 66$) who observed changes in moose numbers over the last approximately 20 years, as well as growth rate of moose abundance and non-Indigenous harvest within each traditional territory and average moose density based on data collected by the province of Ontario over a 16-year time frame (2001–2016). Growth rates were calculated using log-transformed values.

Community	Community perspectives			Provincial moose data		
	Participants who observed an increase in moose numbers (%)	Participants who observed a decrease in moose numbers (%)	Participants who observed no change in moose numbers (%)	Moose population growth rate	Non-Indigenous harvest growth rate	Moose density (/100 km ²)
Biigtigong Nishnaabeg	3	64	33	-0.013	-0.07	26
Magnetawan First Nation	0	87	13	-0.011	-0.12	23
Shawanaga First Nation	7	80	13	-0.011	-0.07	24

I think they've decreased. They've gone up and down but basically when it comes down to it there's less now than there were 20 years ago. – Dawn Gagne, Magnetawan First Nation

[Moose have] definitely decreased. Decreased a lot because I remember going out with my family and we'd be able to catch enough for our whole family and to get enough feed for everyone and now we're lucky if we are able to get some moose. – Eugene Nabigon, Biigtigong Nishnaabeg

Participants expressed concern that observed declines in the moose population were not being appropriately reflected in moose authorizations (i.e., non-Indigenous harvest tags) issued by the Ontario MNRF.

There's a lot of tags being issued [...] primarily in our traditional area. I hear a lot of rumors of the ministry voluntarily decreasing moose populations on purpose for the sole purpose of increasing [...] caribou. And I think that might possibly have an effect on populations [...]. – Stan Nabigon, Biigtigong Nishnaabeg

The Government [is] flooding our traditional area with tags. – Charles Michano, Biigtigong Nishnaabeg

In relation to moose authorizations, participants from both Biigtigong Nishnaabeg and Magnetawan First Nation stated concerns over an observed high number of hunters from outside the community (both Indigenous and non-Indigenous) hunting moose on traditional territories. These concerns were emphasized again during the results-sharing sessions.

I feel like a lot of people not from this region come hunting here and take our moose on us. – Binaeshee Quae Couchi Nabigon, Biigtigong Nishnaabeg

Impacts of moose decline

The response to whether there is enough moose on traditional territories to meet community member needs varied by community. In total, 41% of participants indicated that their needs were met, whereas 48% believed that their needs were not met, and 11% were unsure. The community with the highest proportion of participants that believed that their needs were met

was Shawanaga First Nation (53% of participants), followed by Biigtigong Nishnaabeg (47% of participants). The lowest proportion was in Magnetawan First Nation (13% of participants).

All participants, except for one from Biigtigong Nishnaabeg, indicated concerns over observed declines in moose numbers and how it may affect their way of life. Many concerns were shared across communities, including the effects of moose decline on people's connection with the land and the ability to pass on traditions and knowledge surrounding moose harvesting to younger generations (Table 3).

[A decline in moose is] going to affect the community, it's going to affect the kids' teachings and knowledge. It's going to be a tough go because we rely on it, we depend on it. It's slowly going [to] decrease a lot of traditions, you know all of those traditions that they lost years ago [...]. Some kids are not going to have the feeling [of going] into the bush any more to shoot or work hard for a moose[...] – Anonymous, Magnetawan First Nation

Additionally, a participant from Biigtigong Nishnaabeg emphasized that the community gathering to harvest moose also provided the opportunity for adult community members that have been disconnected from their Anishinaabe heritage to learn traditional teachings and knowledge.

For us, moose is important based on wild sustenance, so food aspects but we also utilize it as teaching methods, so bringing the kids out and making sure that they learn all this stuff that we've never learned either as kids growing up. So, we're also learning alongside them as well. – Juanita Starr, Biigtigong Nishnaabeg

Concern over a decline in ceremonies and gatherings that take place during and following moose hunting was brought up often by participants, particularly those from Biigtigong Nishnaabeg and Magnetawan First Nation. There was further concern over the loss of a sense of community that these gatherings provide, and a loss in the ability to provide food to Elders and those who rely on moose meat for food (Table 3).

When I first hunted, I would always go and give to the Elders [...] that was something that was just an understanding, that we had to give, give to receive. So

Table 3. Effects of moose decline on ways of life described by participants from three Anishinaabe communities.

Effect of moose decline	Example quotation
Disconnection with the land and environment	“Moose are a part of the land and I think they play a very important role in everyone’s life, ‘cause it’s a tradition [...]. Hunting is just a tradition. What we do.” – Eden Twance, Biigtigong Nishnaabeg
Decline in passing on the traditions and knowledge surrounding moose harvest to younger generations	“[Not harvesting moose] would affect our children because they wouldn’t know the traditions and the values of going out to stock the freezer for the winter and so one’s livelihood.” – Gloria Courchene, Biigtigong Nishnaabeg
Decline in ceremonies, gatherings, and traditional and cultural practices	“There are things that we do to help strengthen our hunting. We do ceremony, there are songs that are sung. There’s all kinds of things that we do around the harvesting of that animal, and when we don’t harvest, we don’t learn those ceremonies.” – Roger Jacklin, Magnetawan First Nation
Loss in sense of community and social relationships	“I think if there was no moose, we wouldn’t be out in this territory right now. All gathering as a community with one another.” – Raven Courchene, Biigtigong Nishnaabeg

that’s my way of life, is to give. – Donald Michano, Biigtigong Nishnaabeg

Additionally, participants indicated a high level of concern over moose declines and the impact on their or other community members’ well-being. Concern over food security with a decline in moose was emphasized in all three communities, as well as the resulting health consequences that a change in diet may have or is having on individuals (Table 4).

They used to say [...] that we used to eat fast food, and which is why we hold a lot of weight on us now, because we ate fast food. We are not designed to consume the sugars that we do. But the fast food that we ate was deer, rabbit, partridge, fast food. That was our fast food. – Kimberly Charles, Magnetawan First Nation

That’s why native people have the largest diabetes rate in North America. It’s because our diet has changed quicker than anyone else’s. – Anonymous, Shawanaga First Nation

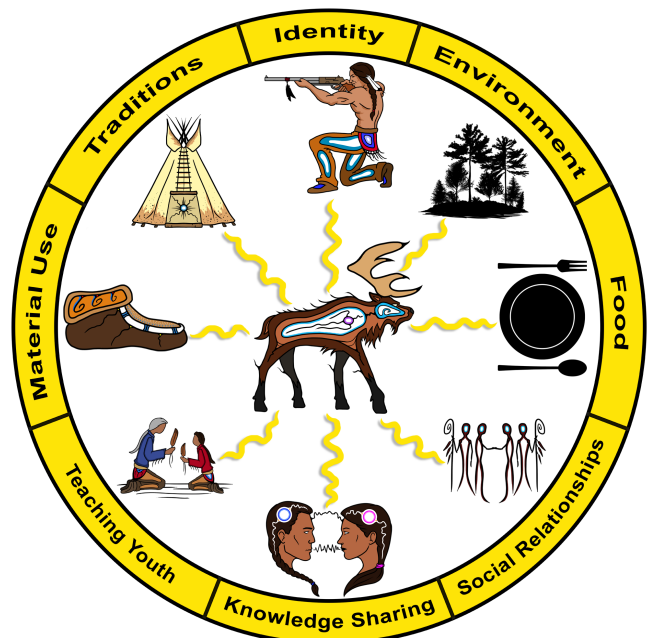
The health issues raised include cancer, diabetes, and weight management. However, not all participants believed that a decline in moose would result in increased health issues, particularly those whose diets did not consist heavily of moose meat.

In addition to affecting physical health, a decline in moose was also anticipated to influence the social and mental well-being of members in each community. While being intertwined with a way of life, moose hunting was described as helping to maintain both a sense of community and the self-identity of community members as part of the Anishinabek Nation. Both aspects were integral to community members’ well-being, and this was expected to decline with moose numbers and harvest, particularly if gatherings and the sharing of moose meat among community members declined (Table 4).

I’d be really concerned [over a decline in moose] because that’s part of who we are. That’s part of our community, part of our lifestyle, moose. We take a lot of pride in the moose [...] I was told that they bring self-esteem too, when you see a moose, it brings self-esteem to the community. – Anonymous, Magnetawan First Nation

A visual summary was prepared to show the different ways moose was described by participants as integral to the way of life and well-being of Anishinaabe People (Fig. 2).

Fig. 2. Visual summary of the importance of moose to the Anishinaabe based on the perspectives of interviewed participants (N = 66) from three Anishinaabe communities in Ontario, Canada. This image was shared with and approved by representatives of each community.

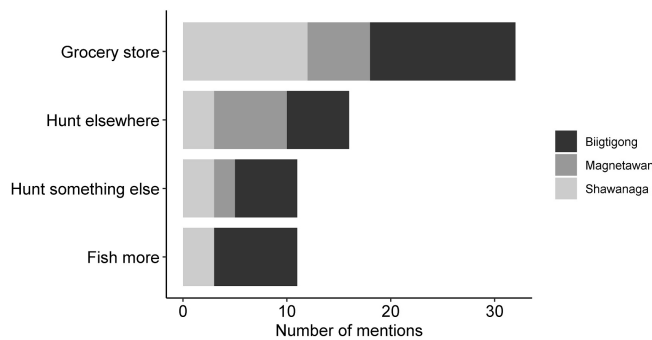


When asked what the alternative to moose hunting would be if moose continued to decline in the traditional territory, most participants from Biigtigong Nishnaabeg and Shawanaga First Nation replied that they would rely more on food from the grocery store, whereas most participants from Magnetawan First Nation replied that they would try hunting for moose elsewhere (Fig. 3). Other alternatives provided by participants included hunting something else such as white-tailed deer, which was described as

Table 4. Effects of moose decline on individual and community well-being described by participants from three Anishinaabe communities.

Effects of moose decline	Example quotation
Decline in food security, particularly in winter	“My concern is that we wouldn’t have enough food for some of our families that rely on [moose].” – Anonymous, Shawanaga First Nation
Increased incidence of health problems (e.g., diabetes, cancer) with increased reliance on store-bought meat	“I believe that without [moose], without the medicine in our system, that we’re more susceptible to sickness, we’re more susceptible to rampant diabetes and that type of stuff.” – Roger Jacklin, Magnetawan First Nation
Loss of self-identity within the community (e.g., Anishinaabe, hunter, provider)	“I think that [harvesting moose provides] a real connection to the community [...]. And if I wasn’t able to hunt and harvest, I wouldn’t [be] able to give as much as I can to the community. So, I think that would really separate me from what I need to do and how I need to feel in my life.” – Donald Michano, Biigtigong Nishnaabeg

Fig. 3. Food-source alternatives to moose hunting, given a decline in moose, mentioned by participants from three Anishinaabe communities. Number of mentions on the x-axis represents the number of people interviewed that mentioned each alternative.



becoming more abundant in each traditional territory, and participants from Biigtigong Nishnaabeg and Shawanaga First Nation indicated that they may rely more on fish as a source of food (Fig. 3). A member of Shawanaga First Nation stated that moose was preferred for taste over the more abundant white-tailed deer.

Support for autonomous moose monitoring

All participants agreed that monitoring the moose population to gain a better understanding of population size and trends, as well as the factors that are affecting moose health and survival, was a good idea. One participant from Magnetawan First Nation indicated that having a better idea of population numbers of moose would be beneficial for community-level harvest management.

Oh yeah big time if that funding is there, especially if it can create a job for somebody. I think that to be really great. And I think it’s very important to be able to know exactly what’s out there so we can be more aware of our harvesting. – Wilmer Noganosh, Magnetawan First Nation

There was also a strong emphasis on the sensitivity of any monitoring information collected and that it should remain protected within the community to prevent misuse. There was a

shared fear among many participants that information such as the location of animals could attract hunters onto traditional territory rather than help to preserve and manage the population.

It would be nice to find out where they bed down, where they do their thing. But the problem with that is it would have to be [...] that nobody really knows about [it], because there’s a lot of people who would go out there and hunt them. – Wanda Noganosh, Magnetawan First Nation

I’d support monitoring the moose but if you tell the general public, we’re going to run out of moose. – Anonymous, Magnetawan First Nation

Support for moose population monitoring at the community level was strongly linked to mistrust in moose monitoring data collected by the MNR (i.e., moose aerial surveys) and how harvest was subsequently managed.

You bet I’d support a moose monitoring system [...] There’s got to be a better way than what the MNR [are doing], just driving around and [using] helicopters, spent 50–60 thousand dollars on a trip to not really get an accurate count. – Jerry Smith, Magnetawan First Nation

It was expressed by multiple participants from Biigtigong Nishnaabeg that community-level monitoring of the moose population would support observations made by community members and enhance the communities’ capacity to manage moose.

I think [moose monitoring is] neat and it’s good. Hopefully it kind of can give some evidence as to what everyone I hear saying and what I notice, [that] there’s less and less moose each year. And if people [are] actually inputting the data and stuff then they can use that to say yeah this is happening and it’s happening here. We need to figure out why it’s happening. – Kim Starr-McWatch, Biigtigong Nishnaabeg

Multiple participants across communities also stressed the importance of community member involvement in monitoring initiatives.

It’s probably something that community members should be involved in. We should know exactly how many animals that we have in our territory. – Anonymous, Shawanaga First Nation

It was emphasized that monitoring initiatives would need to represent the values and needs of the community, have clear objectives, and be conducted in a holistic way that respected Anishinaabe knowledge, perspectives, and inherent rights. It was noted that the capacity to lead community-level monitoring initiatives varied for each community and would therefore need to be addressed and accounted for when developing monitoring programs.

Yes, I do support [moose monitoring] as long as we have enough education, enough resources, enough direction on what our expectations are and what we need to do in order to make sure that we do monitor our moose population in a really good holistic healthy way. So, [...] we shouldn't be expected to monitor it without direction or without guidance [...] in order to monitor it properly. – Carol Twance, Biigtigong Nishnaabeg

A preference for noninvasive methods for monitoring moose numbers (e.g., drones rather than radio-collars) was also indicated. An interest in working collaboratively with neighboring First Nations with overlapping hunting areas, including Shawanaga First Nation, was expressed by a member of Magnetawan First Nation. Many participants also indicated that it is critical that any information collected on moose harvest numbers remain within the communities to ensure that it is used to support self-regulation of the moose population on traditional territory rather than provide outside government the means to regulate Indigenous harvest.

Community-level monitoring of Indigenous moose harvest was also unanimously supported by community members in Magnetawan First Nation and Shawanaga First Nation. In Biigtigong Nishnaabeg, one participant did not support Indigenous moose harvest monitoring and six participants were unsure. The main concern with enforced harvest monitoring was how it may affect Indigenous harvest rights and privacy.

It hasn't got to go that far [...] just to protect people's privacy. You know it's no one's business how much people catch as long as you know they're sharing. – Candy Desmoulin, Biigtigong Nishnaabeg

However, most participants from Biigtigong Nishnaabeg (79% of participants) did support moose harvest monitoring.

I definitely think something like that needs to be done. Because it does take away from the harvest right, it takes away from the population so you should be monitoring things. Traditionally as people we were always traveling, and we would harvest one spot one year and the next move to a different spot. So, I think monitoring and changing things would be a good thing. – Donald Michano, Biigtigong Nishnaabeg

A community member from Magnetawan First Nation highlighted that the ability to monitor community-level harvest and harvest on overlapping traditional territories would depend on the size of the community. They noted that informal tracking of moose harvest in the community and neighboring communities was already occurring through word-of-mouth, and it would be possible to strengthen this approach by working collectively.

You bet I would support some sort of system to monitor just within the community, which we are really at an advantage of Magnetawan because we only have 40 homes. So, you know everybody, you know who hunts. When somebody gets a moose, everybody walks down, looks at it hanging in his tree, or a deer and that. We're small enough that we could monitor accurately as opposed to some communities [...]. It's going to be hard if people's word-of-mouth won't travel that far at times. But here you are on a 1-km road with all 40 homes. So, we are close, and I think there's enough harvesting going on here that you'd get some good numbers and also within the area because of word-of-mouth. We hear when people shoot [a] moose in Henvey, we hear when they shoot them in Shawanaga, so maybe we could build that relationship to "we're all on board". Because I think we all share a common interest in moose. – Jerry Smith, Magnetawan First Nation

Concern over how information on the number of moose harvested by community members would be interpreted was also noted. For example, one participant indicated that it would be difficult to regulate subsistence-based Indigenous moose harvest the same as non-Indigenous harvest with tags or quotas, as this approach does not consider household size or the sharing of moose meat within the community.

We harvest our moose, and our moose goes towards my grandma, my sisters, my mom, my uncle, great uncles. And we distribute amongst our family and there's like, at least 20 to 25 different families. And some of the families are bigger than our home unit. And our home unit consists of maybe 10 to 15 people. So, 10 to 15 of us are sharing one moose. So, if there's bigger families out there like, maybe 30, they might harvest more than one. So, in a way, I guess it could show that we're not over-harvesting, but then at other times it might appear that we are over-harvesting. Then what if that goes to try and put regulations on us. And that's even scarier because that's our way of life. – Kim Starr-McWatch, Biigtigong Nishnaabeg

Some participants indicated that if harvest reporting was to be enforced, the information should be collected by selected or hired members of the community. It was emphasized that decisions for moose management and harvest limits should be made by Chiefs and Elders within each community to ensure that Indigenous inherent rights and ways of life are protected.

I think it would be good to have an idea of how many moose are leaving the area. That type of information would be beneficial. The difficult part is who makes the call when somebody says that we're taking too much. Somebody says that that's too much. I think it needs to be observed, documented, and followed for some time and there has to be some type of recourse for the Elders or the Chief counsel to say no that's enough. – Roger Jacklin, Magnetawan First Nation

A participant from Magnetawan First Nation also stated that they would prefer if hunters from outside the community were required to ask the Chief's permission to hunt in the Nations' traditional territory to limit hunters and prevent over-harvest.

There has to be some kind of system, like when someone wants to hunt here, they have to ask the Chief right? You just can't come into our territory and hunt. So, there has to be some way of monitoring the harvesting, so you don't have ten people up here hunting moose. – Anonymous, Magnetawan First Nation

In general, participants were optimistic that autonomous moose monitoring would help guide community-level decision-making surrounding moose harvest, as well as educate community members on moose ecology and guardianship and open new doors to sharing Anishinaabe knowledge and traditions, particularly to younger generations.

We instinctively have the ability to manage this earth. It's just that when we don't believe in that way of life, when we don't carry that way of life, it's very easy to step outside the bounds of what Mother Nature can handle. [...] Moose is a gift. A really powerful gift that was given to our people to help sustain us. If we lose that medicine, if we lose that gift, then for us to sustain ourselves we have to rely on other sources, grocery stores and whatever you have. I believe that if taken and harvested properly and watched over not only from a government point of view but the traditional point of view, and our First Nations point of view, I think we can work at keeping this here animal, this gift [that is] a sustainable asset for our future food for future generations. – Roger Jacklin, Magnetawan First Nation

Moose growth rates

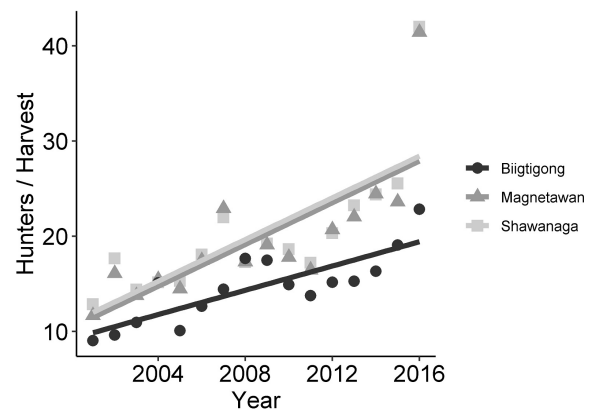
Moose density was highest in Biigtigong Nishnaabeg (26 moose/100 km²), but this territory also experienced the greatest rate of decline in the moose population over the study period (GR = -0.013; Table 2). Moose density was lowest (23 moose/100 km²) and the decline in non-Indigenous moose harvest was greatest in Magnetawan First Nation (GR = -0.12; Table 2). Moose growth rate was the same on the traditional territories of Magnetawan First Nation and Shawanaga First Nation (GR = -0.011), whereas non-Indigenous moose harvest growth rate was the same on the traditional territories of Biigtigong Nishnaabeg and Shawanaga First Nation (GR = -0.07; Table 2). Despite declines in the moose population and non-Indigenous harvest within each traditional territory, the number of hunters had not declined, which resulted in an increasing trend in hunters per moose harvested (Fig. 4).

DISCUSSION

Our study provides evidence of the impacts of a declining traditional food on Indigenous well-being and ways of life through a case study of Anishinaabe perspectives and moose. Observations shared by members of three Anishinaabe communities revealed that moose numbers on traditional territories are declining, which corresponds with moose monitoring data over the last 16 years (2001–2016) collected provincially by the Ontario MNRF. Concerns surrounding moose declines were notably centered around impacts on ways of life and well-being, in addition to food security. In conjunction with noted changes in the moose population, almost one-half of total participants (48%) felt that their needs for harvesting a moose, which included for food and ceremonial purposes, were not being

met. Support for autonomous moose monitoring was almost unanimous across all communities, and we emphasize its use as a means to improve the capacity of communities to respond and adapt to moose declines and ongoing environmental change.

Fig. 4. Change in the number of non-Indigenous hunters per moose harvested over time (2001–2016) in each traditional territory.



Although a decline in the moose population was the most common observation, it was not observed by all participating members of each First Nation. The highest proportion of community members observing a decline in moose was in Magnetawan First Nation, which also experienced the greatest decline in non-Indigenous harvest. Although not directly related, non-Indigenous harvest may reflect Indigenous harvest success because hunters typically hunt in the same areas and during the same time of year. The lowest proportion of community members that observed a moose decline was in Biigtigong Nishnaabeg, despite data indicating that the moose population had the greatest decline in the traditional territory of this community. However, non-Indigenous moose harvest in Biigtigong Nishnaabeg territory had declined the least compared with other traditional territories, suggesting that perceived changes in the moose population may be strongly associated with Indigenous harvest success.

Further, provincial moose harvest data revealed that while non-Indigenous moose harvest on traditional territories was decreasing, the number of non-Indigenous hunters was stable or increasing over time. This finding corresponded with concerns from participants over high moose tags and numbers of hunters from outside the community on traditional territories despite observed moose declines. Moose harvest in Ontario is adaptively managed, and the number of tags allocated can vary year to year (Bottan et al. 2002). Permitting higher hunter group sizes allows for greater non-Indigenous hunter participation in moose hunting without a direct increase in moose tags issued. Permitting greater hunter group sizes per moose tag may, however, be counterintuitive for improving harvest success. Priadka et al. (2020) found that moose harvest in Ontario is nonlinearly related to hunter effort (i. e., number of hunters), and the number of moose killed will level off at high hunter densities. A nonlinear relationship between harvest and hunter effort can be attributed to disturbance from hunter activity that can cause animals to move temporarily out of areas that hunters can easily access (e. g., near roads), particularly

when hunter densities are high (Millsbaugh et al. 2000, McLoughlin et al. 2011). Additionally, regional access management, including road blockages and air transportation bans that are intended to limit hunter access into moose habitat, may result in more aggregated hunter densities and contribute to the displacement of animals (Hasbrouck et al. 2020). Moose displacement following hunter disturbance due to “overcrowding” by hunters may consequently interfere with Indigenous subsistence harvest and result in reduced harvest opportunity for Indigenous hunters. Current harvest management strategies and policy in Ontario may therefore be contributing to food insecurity within Indigenous communities without providing means or capacity to mitigate effects.

Participants in the study indicated that continual moose declines will result in increased reliance on grocery store foods, which have been linked to adverse health consequences for Indigenous Peoples (Young et al. 2000). Health is inclusive of physical as well as mental and social well-being (Isaak and Marchessault 2008), and increased shifts in diet away from traditional foods can exacerbate dispossession from land and way of life and prevent post-colonial healing within Indigenous communities (Marquina-Márquez et al. 2016). Community members also indicated that their diet may change to consist more of fish (Biigtigong Nishnaabeg and Shawanaga First Nation) or other wildlife that are more abundant, including white-tailed deer. Although relying on wildlife other than moose still contributes to maintaining Indigenous Peoples’ connections with the land, traditions and customs specifically associated with moose harvesting may be lost over time. Additionally, while turning to alternative sources of food can provide short-term solutions to address food security, shifting harvest pressure onto other wildlife or fish that are also experiencing environmental stressors may not be sustainable in the long term (Steel et al. 2021).

Furthermore, participants in our study, particularly those from Magnetawan First Nation and Biigtigong Nishnaabeg, indicated that given moose declines on traditional territory, they would try to hunt moose elsewhere. However, this alternative may also have limitations. Indigenous hunters from outside a community are often required to ask the Chief for permission to hunt within a community’s traditional territory. Additionally, costs associated with travelling further to harvest moose may be a limiting factor making it more difficult to rely on traditional foods for subsistence. Incidental costs (e.g., fuel, firearms, ammunition) and time needed to hunt wildlife have previously been identified as major limitations to accessing traditional foods for Indigenous People and therefore need to be equally considered with wildlife declines to address risks to food security (Schuster et al. 2011, Natcher et al. 2016).

As highlighted by our case study, it is increasingly evident that improving the capacity of communities to respond to ongoing environmental changes is needed to address food insecurity and re-establish food sovereignty (Artelle et al. 2019). Food sovereignty through Indigenous-led governance will require a resurgence in policies that accept and include the perspectives and ways of life of Indigenous Peoples, particularly for decision-making related to food access and management (Elliott et al. 2012, Rudolph and McLachlan 2013). Approaching discourse surrounding policy changes in resource management with the

inclusion of ethical space that accepts the worldviews and ways of life of Indigenous Peoples is a step toward decolonization (Ermine 2007) and one that supports social-ecological resilience to ongoing environmental change (Elliott et al. 2012, Huntington et al. 2019, Salomon et al. 2019). Policy surrounding harvested species management needs to respect the social-ecological system between Indigenous Peoples and wildlife and be able to adapt with changes to that system and the needs of Indigenous Peoples (Elliott et al. 2012, Socha et al. 2012). To establish policies that meet community-specific needs, Indigenous knowledge systems, values, and perspectives will need to be equally valued and included in decision-making (Latulippe and Klenk 2020). For example, engagement with First Nations on non-Indigenous harvest levels and hunter effort on traditional territories should take place as an equal partnership rather than a hierarchical process that often ignores the needs and concerns of First Nations (i.e., collaboration as opposed to consultation).

Based on our findings, we recommend that co-management of moose is established or strengthened to support collaborative decision-making through partnership with the Ontario government and First Nations on allocation of both moose tags or quotas and hunter effort. Our study highlights the need to consider and account for the impacts of non-Indigenous hunter effort, particularly hunter group size, on moose displacement and how that relates to Indigenous harvest success. Through collaborative decision-making, hunter overcrowding can be avoided in areas where Indigenous moose harvest occurs. For example, negotiation over access management and the spatial allocation of harvest tags and hunter effort, as well as the timing or length of the non-Indigenous hunting season on traditional territories, may identify options that can better distribute hunter effort across wildlife units and provide improved opportunities for Indigenous Peoples to practice their harvest rights and fulfill their subsistence needs. These decisions may help to reduce the need for Indigenous hunters to travel farther from their communities to harvest moose or rely on other species for subsistence needs, and ultimately may offer a means to reduce food insecurity.

Further, monitoring wildlife is essential for informed decision-making, and when conducted at the community level, it can strengthen negotiating power over jurisdictional decisions to facilitate effective co-management that is truly collaborative (Moller et al. 2004, Popp et al. 2019, Peacock et al. 2020). Community-based monitoring can also invite holistic approaches that improve the capacity of community-level wildlife management (Popp et al. 2019, Thompson et al. 2020). However, barriers to the weaving of Indigenous and western knowledge systems have been ongoing and provide challenges to informing wildlife regulations and decisions that acknowledge different worldviews and ways of life (Padilla and Kofinas 2014). As further highlighted in our study, there is a disconnect between western theory on harvest management and Indigenous wildlife needs that include traditional and ceremonial purposes in addition to food security (Padilla and Kofinas 2014, Peacock et al. 2020).

To be successful, wildlife co-management requires acceptance of knowledge that is co-produced and does not strictly follow western methodologies (i.e., taking counts or measurements), but makes room for different ways of knowing and understanding the

role of wildlife in maintaining well-being and ways of life (Watson 2013). A holistic approach to wildlife monitoring and management can also provide better context to traditional and local knowledge to facilitate how it is weaved with western knowledge systems and ensure that management decisions are applicable to different ways of life (Popp et al. 2019, 2020). Monitoring wildlife and establishing community-led management that respects multiple ways of knowing can not only benefit the conservation of the species but also provide avenues for reinstating community members' knowledge and sense of stewardship that may have been lost due to post-colonial dispossession from the land (Tobias and Richmond 2014, Reed et al. 2020). As environmental changes continue to cause wildlife declines globally, holistic approaches to monitoring and management may be the only solution to address growing food insecurity within Indigenous communities while also supporting Indigenous food sovereignty.

CONCLUSION

Our case study highlights how declines in moose have affected Indigenous food sovereignty, well-being, and ways of life through the perspectives of members of three Anishinaabe communities in Ontario, Canada. We further provide novel insight on how autonomous wildlife monitoring and knowledge co-production at the community level can facilitate co-management of harvested species and inform management practices and policies that recognize and include the perspectives and ways of life of Indigenous Peoples. We focused on moose as a traditional food, but our findings and recommendations for reinstating Indigenous rights and food sovereignty can be applied to all harvested species. We stress that co-management and collaborative decision-making facilitated by community-led wildlife monitoring can be used to address ongoing food insecurities while helping to reinstate Indigenous food sovereignty.

Responses to this article can be read online at:
<https://www.ecologyandsociety.org/issues/responses.php/12995>

Author Contributions:

JNP conceived the study in collaboration with Chief Duncan Michano and Juanita Starr of Biigtigong Nishnaabeg, and PP and JNP developed the manuscript outline. JNP designed interview questions and JNP, CK, and SK facilitated and/or conducted interviews with community members. PP conducted the qualitative and quantitative analyses, interpreted results, and wrote the manuscript. All authors contributed to facilitating results sharing with community members, provided critical feedback on manuscript drafts, and gave final approval for publication.

Acknowledgments:

This project would not be possible without the participation of community members from Biigtigong Nishnaabeg, Magnetawan First Nation, and Shawanaga First Nation who offered to share their knowledge and perspectives on moose. Chi-müigwetch. In addition, several people played a valuable role in this project, including: Chief

Duncan Michano, Juanita Starr, Heidi Manitowabi, Megan Young, Zara Contin, McKenna Elsassner, and Frank Mallory. Figure graphic art was created by Anishinaabe artist Steven Trudeau (<https://www.manitoulingifts.com/trudeau-artwork>). Logistical and/or funding support was provided by Anishinabek/Ontario Fisheries Resource Centre (A/OFRC), Natural Sciences and Engineering Research Council of Canada (NSERC), Canada Research Chair Program, and Laurentian University Advancing Indigenous Research Fund.

Data Availability:

The data that support the findings of this study are available on request from the corresponding author, PP.

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APPENDIX 1. Overview of how interview responses were categorized for data analysis.

Results	Interview questions(s)	Categories/main themes
Experience with moose;	1a. Are you a moose hunter? 1b. Do you eat moose? 1c. How much moose meat do you personally consume on average?	1a. Yes, no 1b. Yes, no 1c. Once a week or more, once or twice a month, several times a year, once or twice a year
Moose importance;	2a. Please describe how moose are important to you and your family?	2a. Sustenance/food security, cultural/traditional, economical, health, environmental, social
Observed changes in the moose population;	3a. Do you think moose numbers have increased, decreased, or stayed the same over the past 20 years in your traditional territory?	3a. Increased, decreased, no change
Impacts of moose decline;	4a. Do you think there is enough moose in your traditional territory to meet your needs? 4b. If moose declined substantially, would you be concerned? If so, why? 4c. Do you think a loss of moose and switch in diet would influence your health? If so, why? 4d. How else do you think a loss of moose would influence you, your community, and/or your traditional way of life? 4e. If your moose hunting success in your traditional territory started to decrease, what would you do? (e.g.: hunt elsewhere, hunt another species, fish more, rely on grocery store meat)?	4a. Yes, no, unsure 4b, c. Yes, no. Well-being: food security, health/diet, self-identity 4b, d. Yes, no. Way-of-life: Connection with the land and environment, traditions and knowledge-sharing, ceremonies/gatherings, social relationships 4e. Number of people that mentioned: grocery store, hunt elsewhere, hunt something else, fish more
Support for autonomous moose monitoring ;	5a. Do you support a moose monitoring system within your community to track moose population trends through time? 5b. Would you support a system that would allow your community to keep track of moose harvest in order to guide internal moose management and conservation initiatives?	5a. Yes, no. Benefits, concerns 5b. Yes, no. Benefits, concerns
