

"I see my culture starting to disappear": Anishinaabe perspectives on the socioecological impacts of climate change and future research needs

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Abstract

Climate change disproportionately affects Indigenous Peoples because of strong connections between environmental, cultural, and spiritual well-being. While much of the global discourse surrounding climate change is founded in Western science, the holistic, place-based knowledge of Indigenous Peoples offers a complementary way of understanding and mitigating climate change impacts. The goal of this research was to elevate Anishinaabe concerns, observations, and perspectives about climate change impacts and future research needs. We organized a workshop called "Connecting Guardians in a Changing World" where participants shared concerns about animal and plant life cycles, water cycles and water quality, and impacts to ways of life, including reduced capacity to perform cultural practices and erosion of their knowledge. Participants highlighted the challenge of prioritizing a single impact of climate change, emphasizing that impacts to the environment and ways of life are interconnected. Participants also expressed the need for research and policy that move beyond interdisciplinarity to include intercultural philosophy and research that better reflects Indigenous worldviews and incorporates Indigenous methodologies. Moving forward, meaningful partnerships and opportunities for knowledge sharing should be prioritized in climate change discourse to ensure solutions are generated together, with all of the tools and knowledge available.

Key words: Indigenous Knowledge, knowledge sharing, environmental change, phenology, monitoring, Indigenous research priorities, socioecological systems

Introduction

Climate change is one of the most important issues facing the globe today. Growing concentrations of greenhouse gases are causing average temperatures and sea levels to rise, precipitation patterns to change, snow and ice cover to decrease, and extreme weather events (e.g., heat waves, floods,

wildfires) to become more frequent and intense (Intergovernmental Panel on Climate Change (IPCC) 2014; Bush and Lemmen 2019). The current environmental crisis is thought to be predominantly caused by developed nations (i.e., due to higher greenhouse gas emissions; Mattoo and Subramanian 2012; Matthews et al. 2014), which are often associated with worldviews that view nature as a commodity to be dominated and (or) managed for the benefit of humans (McGregor 2018). However, the compounding impacts of this crisis fall disproportionately on Indigenous Peoples, because of their close ties to the land for sustenance, culture, well-being, and the widespread impacts of colonialism that continue to disrupt and undermine their political, cultural, and socio-economic systems (Tsosie 2007; Whyte 2017; Chisolm Hatfield et al. 2018; Human Rights Watch (HRW) 2020).

As the environment continues to change, the socioecological impacts of climate change on Indigenous Peoples are becoming increasingly apparent. Changes in the distributions, life cycles, behaviour (e.g., migration), productivity, and health of species used for food and medicine are making it increasingly difficult for Indigenous Peoples to harvest these species and interact with the land in the ways their families have for generations (Guyot et al. 2006; Ford et al. 2013; Settee and Shukla 2020). Unpredictable weather patterns and changes in ice and snow conditions are making harvest activities costlier, more dangerous, and sometimes even impossible (Laidler et al. 2009; Lynn et al. 2013; Derksen et al. 2019). Reduced access to traditional foods and medicines, less time out on the land, and water quality issues are all linked to adverse effects on physical health (Richmond et al. 2005; Harper et al. 2011; Berrang-Ford et al. 2012; Ford 2012). And, ultimately, for people and entire nations whose sense of community, identity, and well-being emerge from strong connections to the land and to place (Adelson 2000; Wilson 2003; Parlee and Berkes 2005; Kral et al. 2011; Mikraszewicz and Richmond 2019), these biophysical changes and disruptions to ways of life are linked to declining emotional, spiritual, and sociocultural well-being (Berry et al. 2010; Furberg et al. 2011; Cunsolo Willox et al. 2012; Ford 2012; Willox et al. 2015; Cameron et al. 2021).

While Indigenous Peoples are widely acknowledged to be highly vulnerable to the impacts of climate change, their unique knowledge systems and experiences remain vastly underrepresented in discourse surrounding climate change impacts and, particularly, solutions for the future (Ford et al. 2016; Makondo and Thomas 2018; Latulippe and Klenk 2020). Although Indigenous worldviews are diverse, there are common philosophical and spiritual underpinnings that guide relationships with the natural world, centered around respectful relationships, environmental sustainability, and persistence for future generations (Simpson 2000; McGregor 2018; Nelson and Shilling 2018; Whyte 2018). Plus, because of holistic relationships with the environment and associated phenologies, Indigenous Knowledge has potential to identify changes undetected by Western science, including in-depth, place-based observations of environmental change over greater time-scales than Western science allows (Gagnon and Berteaux 2009; Whyte 2017; Chisolm Hatfield et al. 2018). Moreover, Indigenous Peoples have developed a capacity for adaptation and resilience through generations of surviving environmental change (Turner and Clifton 2009; Whyte 2017) including the undermining of political, economic, legal, and governance systems through historical and ongoing colonial policies and practices of cultural genocide (Reo and Parker 2013; The Truth and Reconciliation Commission of Canada (TRC) 2015; Makondo and Thomas 2018; National Inquiry 2019). As such, creating space for Indigenous voices in climate change research and decision-making will provide a more robust and accurate characterization of environmental change and associated socioecological impacts, as well as “instructions” for adaptation, sustainability, and living in harmony with the environment (Turner and Clifton 2009; Ford et al. 2016; Makondo and Thomas 2018; Cameron et al. 2021).

In this paper, we present observations, concerns, and knowledge shared in a regional workshop with Elders, youth, and environmental professionals representing 12 Anishinaabek communities in the

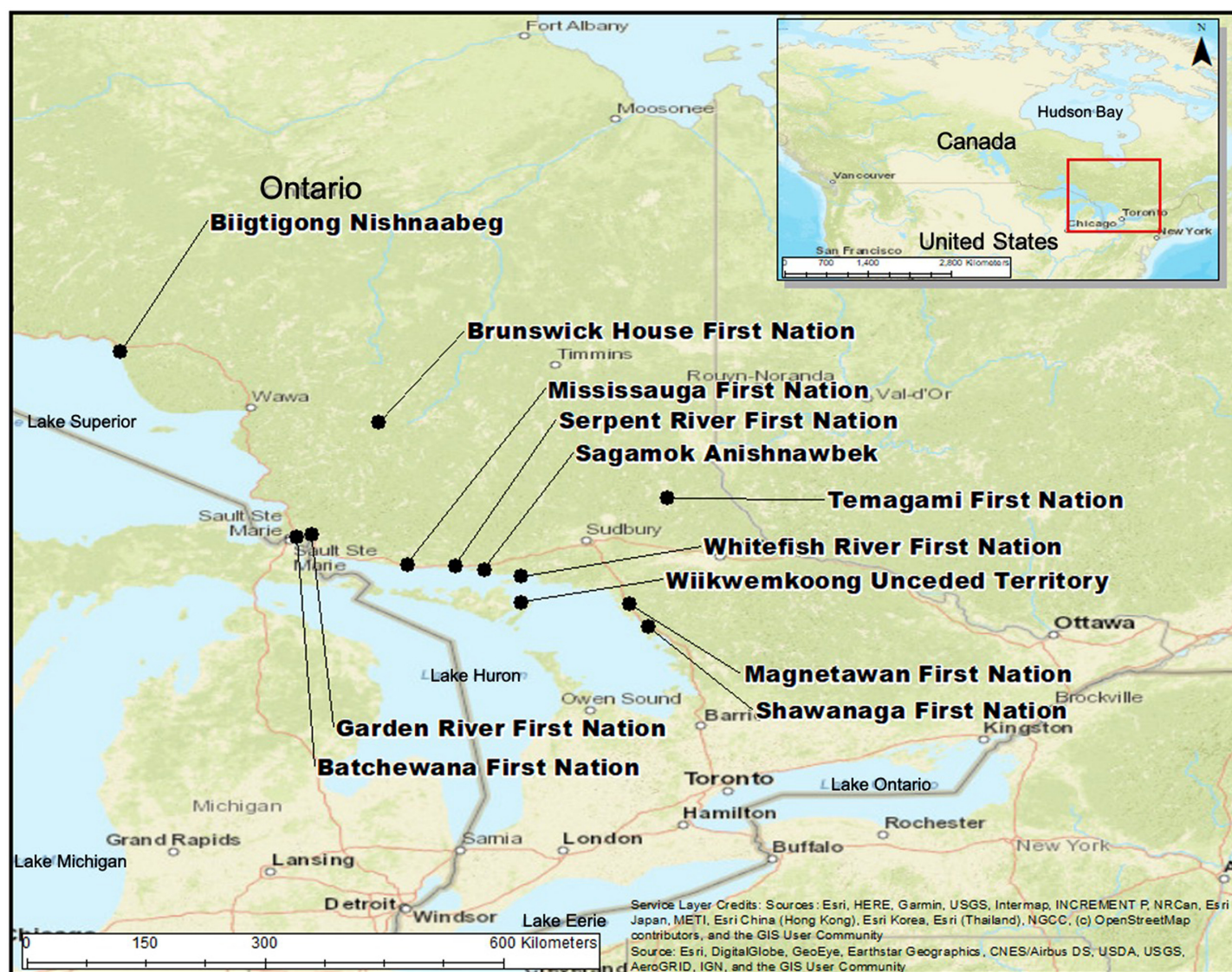


Fig. 1. The locations of the 12 Anishinaabek communities who participated in the “Guardians in a Changing World” workshop.

Great Lakes region of the Robinson–Huron Treaty Area (Ontario, Canada; [Fig. 1](#)). Through a number of sharing circles, we discussed three main topics related to climate change: (i) key concerns related to the environment, (ii) key concerns related to community and ways of life, and (iii) future research priorities. The knowledge and experiences we share throughout this paper are both place- and context-specific, illustrating unique, local observations of climate change impacts on the Great Lakes region of Canada and Anishinaabe ways of life. This knowledge is accumulated through generations of lived experience and particular relationships with the land and cannot be separated from the people and the places that hold and (or) practice it ([McGregor 2004, 2018](#); [Latulippe and Klenk 2020](#)). However, when considered alongside knowledge shared by other Nations (e.g., [Guyot et al. 2006](#); [Cunsolo Willox et al. 2012](#); [Ford et al. 2013](#); [Brinkman et al. 2016](#); [Cameron et al. 2021](#)), it reveals how climate change impacts and priorities are both the same and different across locations and

contexts. Considering the magnitude of the current environmental crisis, all available knowledge and expertise, including Indigenous and Western, from local to global scales, will be essential for identifying, understanding, and mitigating the multidimensional impacts of climate change.

Research approach and methods

This research was led and conducted by Indigenous Peoples and communities, and their allied researchers. It was co-developed and conducted in partnership between the academic research team and Magnetawan First Nation in response to local concerns, observations, and research needs. Individuals from Magnetawan First Nation and other participating communities gave approval for the research and subsequent publications and provided feedback and results validation through surveys, oral presentations, and feedback forms. We obtained informed consent from all participants and had Research Ethics Board ethics approval from Mount Allison University and the University of British Columbia (Okanagan) (H19-01453).

Our approach

The purpose of this paper was to share perspectives, experiences, and knowledge of Anishinaabek communities and advocate for the inclusion of Indigenous Knowledge, research methodologies, and priorities in climate change discourse. This research provides an example of truly Indigenous-led climate change research; it was motivated by community concerns, developed and implemented by Indigenous communities and allied researchers, uses Indigenous research methodologies, and addresses issues that are important to the communities involved. Our authorship team consists of both Indigenous and non-Indigenous researchers from biology, law, and environmental sciences; environmental professionals; and Indigenous Knowledge holders with lived experience in Anishinaabe ways of knowing. At the core of our research approach is partnership, respect, and reciprocity among Indigenous and non-Indigenous partners to ensure that the knowledge, concerns, and priorities shared throughout were not misinterpreted or appropriated and are based on the perspectives and needs of everyone. Ultimately, we aim to generate climate change research, policy, and decision-making that holds deliberate and respectful space for Indigenous Peoples to share their knowledge, traditions, and values; an approach that will, ultimately, ensure important decisions are made with all of the available tools and knowledge and are in the best interest of everyone and the planet.

“Guardians in a Changing World” workshop

In November 2019, environmental professionals, Elders, and youth from 12 Anishinaabek communities in the upper Great Lakes region of the Robinson–Huron Treaty Area were invited to participate in a two-day workshop called “Connecting Guardians in a Changing World”. The workshop was hosted initiated and by Magnetawan First Nation and included individuals from Batchewana First Nation, Garden River First Nation, Sagamok Anishnawbek, Serpent River First Nation, Shawanaga First Nation, Temagami First Nation, Whitefish River First Nation, Wiikwemikoong Unceded Territory, Biigtigong Nishnaabeg, and Brunswick House First Nation (see [Fig. 1](#) for map). Invitations were sent to a representative from each of the community’s Lands/Natural Resources department who then worked with the community to invite an Elder or knowledge holder and one youth (age 19–30 years) to attend the workshop. In total, 37 individuals participated, including 8 Elders, 3 knowledge holders, and 15 youth. To open communication between facilitators and participants, each participant received a tobacco tie, and each day was opened and closed in ceremony. Elders also received an honorarium. The objectives of the workshop were to bring community members together to discuss environmental concerns, one of which was climate change.

At the workshop, the 37 participants were divided into four sharing circles to discuss a series of pre-determined, open-ended questions over two days. Sharing circles, which are similar to focus groups, represent an Anishinaabe data gathering and knowledge sharing method allowing for nonhierarchical open conversation that facilitates a transfer of knowledge, storytelling about lived experiences, and observations (Tachine et al. 2016). Each of our sharing circles consisted of six or seven individuals and were led (in English) by a facilitator from the research team. The audio of each sharing circle was recorded for transcription at a later date. Three major themes were discussed in each sharing circle: (i) the greatest climate change concerns related to the environment, (ii) the greatest climate change concerns related to community and ways of life, and (iii) climate change research priorities and future directions. After the sharing circles concluded, facilitators met to determine the five most common responses under each theme and shared these with the larger group. All participants were then asked to place a single sticker next to the one statement they felt was the most important under each theme, such that each participant only placed three stickers (one sticker for each theme; Fig. 2). The statements with the most stickers were considered to be the most important climate change concerns and (or) research priorities (see Table 1).

Audio recordings from the workshop were transcribed using Trint (www.trint.com), and then manually verified by the research team. Unless explicitly identified in the recording, all information provided in the interviews was kept anonymous. Transcripts were coded by hand. We used our three workshop objectives (i.e., impacts to the environment, impacts to traditional ways of life, and future research directions) as the broadest themes for coding and then further categorized quotes into subthemes that emerged from participants' observations and perspectives during the workshop

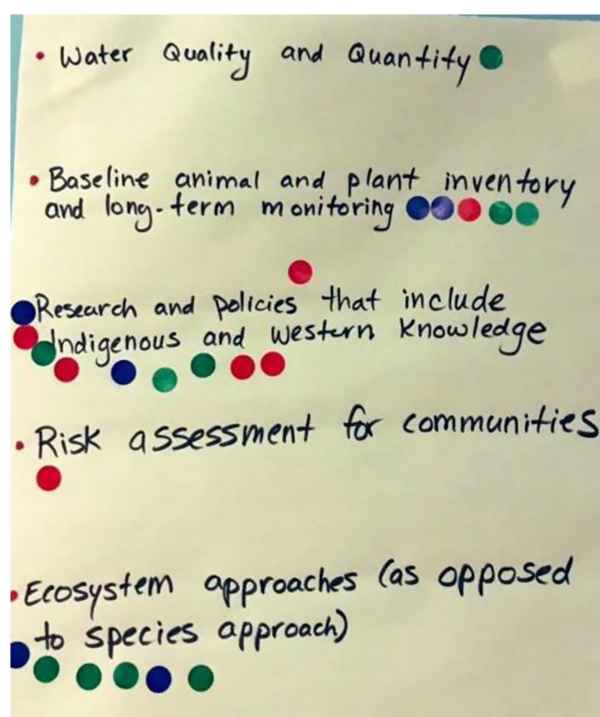


Fig. 2. A photo of the dot-voting exercise outcome for the “Research Priorities” theme. Each workshop participant was asked to place a sticker next to the single statement they thought was the most important research priority.

Table 1. Results of the dot-voting exercise demonstrating the top concerns and (or) priorities for each of the three discussion themes.

Concern or priority	Number of votes
Greatest concern for the environment	
*Animal and plant life cycles are changing	9
*Water cycle and quality are changing	8
Biodiversity is shifting	4
Disease and parasites	2
Animal and plant distributions are changing	1
Total = 24	
Greatest concern for community and ways of life	
*Traditional and spiritual practices	13
*Understanding the land is becoming more difficult and unpredictable	9
We need to identify where to allocate resources	2
Decreased opportunities to harvest wildlife and medicines	0
Limited capacity of communities to address climate change	0
Total = 24	
Future research priorities	
*Research and policies that weave Indigenous and Western knowledge	9
*Baseline animal and plant inventory and long-term monitoring	6
*More holistic, ecosystem-level approaches	6
Risk assessment for communities	1
Water quality and quantity	1
Total = 23	

Note: Workshop facilitators recorded the top concerns/priorities during the discussions in each sharing circle, then workshop participants voted on which they thought was the most important within each category. Participants could only vote once per category. The concerns/priorities marked with an asterisk (*) are discussed further in the results and discussion section.

(i.e., the dot-voting exercise) and the transcripts themselves (e.g., for environmental concerns, sub-themes included animals, life cycles, water, etc; for more detail, see [Supplementary Materials](#)).

Results and discussion

Through our two-day workshop we heard Anishinaabe perspectives, experiences, observations, and knowledge all pointing to severe and daunting socioecological impacts of climate change, including impacts on the timing of important life cycles, cultural and spiritual practices, and challenges for maintaining knowledge systems. While we separated our discussion points into environmental and cultural impacts, and share results separately, below we also discuss insights from participants, provided as direct quotes, as to why this separation is problematic and challenges Indigenous world-views. Related to this or, perhaps as a result, participants highlighted a need for more holistic research approaches and emphasized a need for more respectful engagement with Indigenous communities and prioritization of Indigenous Knowledge in climate change discourse. The workshop discussions further emphasized the vulnerability, strengths, and resilience of Indigenous Peoples, a paucity of

meaningful engagement with Indigenous communities in climate change policy and decision-making, and the potential contributions of Indigenous Knowledge to climate change research and adaptation planning into the future.

Climate change impacts on the environment

“Our calendar system in Ojibwe, we have 13 months rather than 12, and each one is named something based on what happens during that moon. Which is frightening because those things are changing.” —Anonymous interview participant

Workshop participants identified shifts in animal and plant life cycles and the timing of natural phenomena as the top concern related to climate change impacts on the environment (9 of 24 participants). Some participants spoke generally of changes in all life cycles, but others provided specific examples like changes in the timing of bird migration, growth of important plants (e.g., maple trees, berries), hibernation patterns of wildlife (e.g., snakes), and the timing and duration of snow and ice cover. Phenological events, or the seasonal/periodic events in plant and animal life cycles, are considered highly sensitive to environmental variation and climate change (Friedl et al. 2014; Thackeray et al. 2016). Generally, in the northern hemisphere, events associated with spring appear to be occurring earlier and autumn events are delayed (Menzel and Fabian 1999; Steltzer and Post 2009). Both Western scientific and Indigenous knowledges suggest shifts in the timing of migration (caribou, Le Corre et al. 2017; migratory birds, Murphy-Klassen et al. 2005; Guyot et al. 2006), running and spawning of fish (Jacob et al. 2010), snow and ice dynamics (e.g., freeze-up, melt; Guyot et al. 2006; Laidler et al. 2009; Tam et al. 2013; Proverbs et al. 2021), and reproductive timing of animals and plants (Todd et al. 2011; Lynn et al. 2013). Differences in the impacts to and responses of various plant and animal species to environmental changes are also creating “mismatches” between species (e.g., predator–prey or herbivore–plant interactions; Thackeray et al. 2016; Peers et al. 2020), and between wildlife and their environments (e.g., breeding mismatched with food availability; Doiron et al. 2015; Lameris et al. 2018). Not only are these seasonal changes affecting the health and well-being of the environment, but they are also making it difficult for people to predict where and when to access important foods and medicines (Guyot et al. 2006; Jacob et al. 2010; Moerlein and Carothers 2012; Lynn et al. 2013; Brinkman et al. 2016; Proverbs et al. 2021).

“... Harvesting medicines is becoming difficult. Well, you know, it used to be like ‘June is when we’re going to go harvest strawberries’ [but] we don’t get them until July. The end of June, early July was the time we needed to go harvest birch bark. This year [2019] when we harvested birch bark, we had less than two weeks and we usually have one month. Harvesting winter bark, you know, the time to harvest winter bark would probably be right now [November]. Probably now for a month. Now the best time to harvest is less than two weeks.” —Anonymous interview participant

Another concern related to the environment was changes in increasing water temperatures, threats to water quality, and changes in water cycles (8 of 24 participants). Participants expressed concerns for downstream effects of increasing water temperatures on aquatic organisms and, consequently, access to them.

“I’ve noticed with respect to climate change that [...] the variances in the water temperature raising is pretty alarming. How we can tell when the fish, the pickerel, the walleye are done spawning is that we start to see bass, we start to see bass in, and it means that the river water is lowering [and] the water temperature is also rising. And so, we are noticing that the actual duration for the fish spawning period in the hatchery or in the river used to [be] over a

month, this year we were lucky to get about two and a half weeks. Which is pretty scary because I think it is pretty detrimental.”

Indeed, research indicates that climate change is causing substantive changes in aquatic ecosystem dynamics, including increases in temperature and acidification, which are impacting fish distributions (Perry et al. 2005; Proverbs et al. 2021), timing of spawning events (Jacob et al. 2010; Pankhurst and Munday 2011), behaviour (Moerlein and Carothers 2012), and health (e.g., contaminant exposure, Noyes et al. 2009). Changes in the timing and abundance of fish are highly problematic for Indigenous communities that rely on traditional fishing practices for sustenance (Jacob et al. 2010; Moerlein and Carothers 2012). Climate change is also impacting water levels in local creeks, rivers, and lakes (Guyot et al. 2006) as well as water quality (Delpla et al. 2009), which could increase the risk of waterborne disease (Harper et al. 2011). Notably, many Indigenous communities are already faced with a water crisis because of limited or nonexistent infrastructure and political inequality (Meehan et al. 2020; Arsenault 2021), so even subtle environmental changes could exacerbate water-related health risks that already disproportionately affect Indigenous people.

Climate change impacts on ways of life

“The climate change impacts to those [animals and environment] will actually impact our community and way of life.”

When considering the impacts of climate change on their communities and traditional ways of life, workshop participants expressed the greatest concern for their capacity to perform cultural and spiritual practices (13 of 24 participants). Indigenous Peoples have an interdependent relationship with the land where identity, culture, and spiritual well-being emerge from one’s connection to the land and to place (Adelson 2000; Wilson 2003; Parlee and Berkes 2005). Therefore, changes to the land or reduced time spent on the land can lead to cultural disruption and can affect sense of self and cultural identity (Middleton et al. 2020). Many did not mention specific practices but, rather, emphasized the concern for their culture, beliefs, and teachings as a whole.

“The Anishinaabe values, Anishinaabe teachings, Anishinaabe culture and all those teachings and knowledge come from the animal and plant life, the way we behave, the way we teach, and we interact with each other and those teachings come from the animals.”

Similar sentiments have been shared by Indigenous Peoples from around the globe; changes in environmental conditions, the timing of natural events, and access to wildlife and medicines are impacting cultural practices from traditional harvest methods to canoe making, music, dance, art, and spirituality (Guyot et al. 2006; Brosi et al. 2007; Sakakibara 2009; Jacob et al. 2010; Allison 2015; Harrison 2020).

Second, workshop participants were concerned about the potential erosion of their land-based knowledge systems as the land continues to change: “You can’t read what’s going on around you, you can’t read the water, it’s hard to read the sky. Things are getting difficult.” Indigenous Knowledge is defined by place, specifically by intimate relationships with the land, water, and wildlife therein (Berkes 2018). One participant spoke of the critical role of wildlife in the knowledge systems of Indigenous Peoples stating: “the species are knowledge keepers themselves”. As wildlife populations decline and (or) become less accessible, not only are land-based activities (e.g., harvest) becoming more challenging, but opportunities to learn from nonhuman knowledge keepers are becoming increasingly rare. While Indigenous Knowledge is ever-changing and adaptive, renewed by each succeeding generation (Berkes 2018; Kimmerer 2018), participants were concerned that the rate of environmental change is too rapid to adapt to: “... climate change is happening so fast that we can’t—our Traditional

Knowledge can't-keep up, then you're going to lose something along the way". Ultimately, as the land continues to change and becomes unfamiliar, workshop participants expressed concern that their knowledge systems will erode over time and, eventually, be lost. This is already occurring and causing emotional distress for knowledge holders, who find it challenging to mobilize knowledge, and for youth, who are trying to connect with the land and animals but are having a hard time.

"The kind of social impacts and emotional impacts that [climate change] has when you were so ingrained in that way of life, when you are so deeply ingrained in that knowledge, those relationships with the land, and you go and try to mobilize what you know and trying to share that with other people and as soon as you go to do it, it's like, you know, now's not the time. And it's really discouraging. It's disheartening and it's definitely frustrating for all people that carry that knowledge."

"... youth have been identifying that they want to be out there learning those things and connecting to those animals. But when they're changing and they're leaving and there's less of them, it's a lot harder for the youth to get those connections and start to learn their culture. And, as a whole family, the way that we were supposed to do it"

Threats to land-based knowledge, including navigational skills and knowledge of traditional hunting practices, have been reported in other Indigenous communities (Guyot et al. 2006; Laidler et al. 2009; Athayde et al. 2017; Proverbs et al. 2021), suggesting a more widespread and, perhaps, understated and time-sensitive impact of the current environmental crisis.

Socioecological impacts of climate change

"When I see species starting to disappear, I see my culture starting to disappear."

While we separated our discussion points into environmental and cultural impacts of climate change, we heard very strongly that this separation is problematic and challenges Indigenous worldviews. A prominent message that emerged from the sharing circles was the difficulty for participants to separate concerns related to the environment and concerns related to community and traditional ways of life. Generally, participants spoke to the challenge of pinpointing a single concern: "We don't really have a greatest [climate change] concern. It's all interconnected." Indigenous Peoples share a worldview of interdependence, connectedness, relatedness, and co-existence between nature and all living creatures (Michell 2011; Martinez 2018; McGregor 2018), making it difficult to separate effects of climate change on the environment from effects to culture, way of life, health, and well-being (Moerlein and Carothers 2012; Mikraszewicz and Richmond 2019):

"... I think about our entire culture as a whole and how those species start disappearing, our culture is going to start disappearing. Because, like my mom said this morning, those animals, they're our teachers, our relatives, our clans. And if we can't make those connections and learn from those animals, our cultures are going to start disappearing, and then it's going to be all over, and I can't go out on the land and do those things."

These discussions further reinforce the vulnerability of Indigenous Peoples to climate change due to the strong connections between environmental well-being and ways of life which, ultimately, affect physical health, cultural integrity, and emotional well-being (Parlee and Berkes 2005; Richmond et al. 2005; Turner and Clifton 2009; Kral et al. 2011). It also highlights the limitations of Western scientific approaches to climate change research and decision-making, which tend to separate ecological, social, cultural, and health impacts into separate disciplines.

Future research priorities

“Traditional Knowledge is scientific knowledge.”

Beyond discussing impacts to Anishinaabe ways of life, we discussed community priorities for climate change research moving forward. Generally, the top research priorities were broad and related to how environmental research is conducted and less related to specific environmental concerns that emerged in the first two questions (e.g., water quality was a top concern but not a top research priority). The top research priority (9 of 23 participants) was to develop research and policies that include Indigenous and Western knowledges, together. Despite the disproportionate impact of climate change on Indigenous Peoples, environmental research, management, and associated decision-making processes in Canada have a history of exclusion of Indigenous voices and, to this day, remain guided primarily by Western science based knowledge systems and processes (e.g., [Binnema and Niemi 2006](#); [Eckert et al. 2020](#); [Latulippe and Klenk 2020](#); [Reid et al. 2020](#)). “The value of Indigenous Knowledge isn’t taken as seriously by Western ways of knowing. [...] Western science, it can contribute, but it’s not the be all end all.” Indigenous Knowledge can provide observations and in-depth knowledge on local changes in ecological processes and (or) relationships in ways that Western science cannot. Complex environmental issues, like climate change, could benefit substantially from approaches that braid together Indigenous and Western ways of knowing ([Turner and Clifton 2009](#); [Ford et al. 2016](#); [Makondo and Thomas 2018](#); [Cameron et al. 2021](#)). For example, Two-Eyed Seeing is a process described as learning to see from one eye with the strengths of Indigenous Knowledge and ways of knowing, and from the other eye with the strengths of Western knowledge and ways of knowing, but using both eyes, together, to work towards shared goals ([Bartlett et al. 2012](#); [Reid et al. 2020](#)). Ultimately, Two-Eyed Seeing and similar models (e.g., the Two-Row Wampum; [McGregor 2011](#); [Latulippe 2015](#)) that truly respect the strengths and validity of both Indigenous Knowledge and Western science will ensure that important decisions are made with all of the tools and knowledge available and will create a path forward for climate change research and policy that are rooted in mutually beneficial outcomes, good relationships, and reconciliation with each other and the Earth.

However, workshop participants voiced concerns and reservations related to weaving Indigenous and Western ways of knowing, emphasizing the need to do it in a “good” way. Individuals voiced frustrations over past experiences, including insufficient engagement done simply “to check a box”. Others shared that Indigenous Knowledge is disrespected, reduced down to data, or used as a means to support Western scientific findings, with very few examples where Indigenous Knowledge and values were effectively prioritized (see also [David-Chavez and Gavin 2018](#); [Latulippe and Klenk 2020](#)).

“I did a little research into this and how it works, how the [knowledge systems] work together currently in the system [...]. There’s definitely some positive examples, but there’s also a lot of negative examples where the Indigenous Knowledge is not seen as the same. Or they use, you know, they’ll go out and they’ll ask people questions and they’ll go get the Western scientists to go and confirm what the Elders and the medicine people are already saying. So, I think the suggestion would be definitely to never reduce Indigenous Knowledge down to data.”

Workshop participants suggested holding future workshops to share perspectives and discuss how to create ethical space ([Ermine 2007](#)), an approach that holds space for both Western science and Indigenous Knowledge, values, and worldviews simultaneously. We recommend that researchers and decision-makers make this a priority. As well, non-Indigenous environmental researchers, managers, and policy makers must acknowledge and challenge current power imbalances and prioritize meaningful relationships with Indigenous partners to ensure that Indigenous Knowledge and research methodologies are truly valued and respected instead of being appropriated and (or) misinterpreted ([McGregor 2014](#); [Latulippe 2015](#); [Hovel et al. 2020](#); [Wong et al. 2020](#); [Hessami et al. 2021](#)).

The next two research priorities identified by workshop participants provided tangible instructions on how to undertake Indigenous climate change research, or research that better reflects Anishinaabe worldviews and teachings. First, workshop participants emphasized that typical species-specific approaches to wildlife monitoring and management do not properly capture the impacts of climate change on the environment nor will they be effective in mitigating the widespread effects. Instead, they (6 of 23 participants) expressed a need for more holistic approaches to climate change research. For some this meant research focused on “the whole system, not just the species” (i.e., community or ecosystem-level approaches) and for others it meant more interdisciplinary research that captures climate change impacts on environmental, physical, emotional, spiritual, and cultural well-being at the same time. “I think more about the whole interconnectivity. [...] looking at the spiritual component and everything. That type of research has yet to even be done...” Using more holistic approaches to describing and understanding climate change impacts has potential to capture more nuanced impacts (on all species, not just keystone species) and create added value of research, as it would capture not only environmental impacts but also the socioecological impacts. Indigenous Knowledge—a more holistic way of viewing and understanding the world—could provide the foundation for such approaches moving forward.

Finally, the third primary research priority (6 of 23 participants) was to obtain more baseline information and conduct more thorough environmental monitoring: “I think knowing what those indicators [species] are, but also how they’re changing [over time].” There is a recognized, universal need for baseline information to detect changes in the environment and assess success of current and future management decisions (Harper et al. 2011; Lindenmayer et al. 2015). But, beyond that, participants expressed a specific need for external support—financial and logistical—to build Indigenous-led monitoring programs that recognize the rights, values, and customs of Indigenous Peoples. Community-based or Indigenous-led monitoring programs are emerging across Canada and the globe. Such initiatives have proven to be effective at gathering rigorous data about the environment through both Indigenous and Western knowledge; building collaboration among Indigenous and non-Indigenous researchers, managers, and decision-making bodies; building local research capacity; and revitalizing knowledge systems and connection to the land (Kouril et al. 2016; Timoti et al. 2017; Gérin-Lajoie et al. 2018; Wilson et al. 2018; Mikraszewicz and Richmond 2019; Thompson et al. 2019; Hovel et al. 2020; Popp et al. 2020; Reed et al. 2021). In Canada, Crown governments—federally and regionally—have begun to invest in Indigenous-led environmental monitoring (e.g., Indigenous Guardians Pilot, Indigenous Community-Based Climate Monitoring Program), but more work needs to be done to guarantee the long-term success of these initiatives, and to ensure information gathered through these programs actually inform decisions and policy that affect Indigenous lives and lands (Hessami et al. 2021).

Conclusions

Observations, experiences, and knowledge of Anishinaabek communities of the Great Lakes region, indicate that the timing of important life cycle events, water cycles and temperatures, biodiversity, and access to important species are all being impacted by climate change. These biophysical changes in the environment are affecting traditional livelihoods, including the capacity to perform cultural and spiritual practices and the ability to acquire and transfer knowledge to future generations, which has cascading effects on physical, cultural, and emotional well-being. The emphasis placed on the inextricable connections between the environment and ways of life reinforce the unique and harmful impacts climate change has and will continue to have on Indigenous Peoples. It also highlights limitations of Western scientific approaches to understanding and mitigating climate change impacts, which often separate complex systems into smaller components and do not easily capture the emotional, cultural, and spiritual elements of relationships in the natural world. Future research must

confront how climate change impacts are characterized and interpreted (i.e., species specific and interdisciplinary vs. ecosystem wide and more holistic), move beyond interdisciplinary science towards cross-cultural understandings, and challenge who is involved in on-the-ground efforts, important discussions, and policy decisions.

Kimmerer (2018, p. 47) said that “[Western] science is a superb tool for answering true/false questions, but it does not have the capacity to address questions of right/wrong. Indeed, many of the complex issues we face today lie at the intersection of nature and culture, and leaders and policy makers, as well as scientists, acknowledge that [Western] science alone is not sufficient to address them”. Although Western science can describe the natural world, it does not speak to “how” to live respectfully with nature (McGregor 2018). Indigenous Knowledge, built on respect, reciprocity, and responsibility (Kimmerer 1998; Pierotti and Wildcat 2000), provides “original instructions” for caring for and relating to the land (McGregor 2004, 2018; Cajete 2018; Cameron et al. 2021). Moving forward, approaches that respectfully and meaningfully braid together Indigenous and Western knowledge (e.g., Two-Eyed Seeing), and promote respectful partnerships among Indigenous and non-Indigenous nations, will not only help restore the land and systems damaged by climate change, but also heal our relationship with the land through reciprocity, responsibility, and reconciliation (Kimmerer 2018; Cameron et al. 2021). Together, our collective knowledge systems, values, and ways of knowing have the potential to transform and restore our relationships with all our relations in the hopes of maintaining the integrity of socioecological systems for future generations.

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Author contributions

EB, CK, SC, DM, AF, and JNP conceived and designed the study. EB, MG, HP, CK, SC, DM, and JNP performed the experiments/collected the data. AKM, EB, MG, HP, CK, SC, DM, and JNP analyzed and interpreted the data. CK, DM, AF, and JNP contributed resources. AKM, EB, MG, HP, CK, SC, DM, AF, and JNP drafted or revised the manuscript.

Data availability statement

All relevant data are within the paper and in the Supplementary Material.

Supplementary material

The following Supplementary Material is available with the article through the journal website at doi:[10.1139/facets-2021-0066](https://doi.org/10.1139/facets-2021-0066)

Supplementary Material 1

References

- Adelson N. 2000. 'Being alive well': Health and the politics of Cree well-being. Vol. 16. University of Toronto Press, Toronto, ON.
- Allison EA. 2015. The spiritual significance of glaciers in an age of climate change. *Wiley Interdisciplinary Reviews: Climate Change*, 6(5): 493–508.
- Arsenault R. 2021. Water insecurity in Ontario first nations: An exploratory study on past interventions and the need for Indigenous water governance. *Water*, 13(5): 717. DOI: [10.3390/w13050717](https://doi.org/10.3390/w13050717)
- Athayde S, Silva-Lugo J, Schmink M, and Heckenberger M. 2017. The same, but different: Indigenous knowledge retention, erosion, and innovation in the Brazilian Amazon. *Human Ecology*, 45(4): 533–544. DOI: [10.1007/s10745-017-9919-0](https://doi.org/10.1007/s10745-017-9919-0)
- Bartlett C, Marshall M, and Marshall A. 2012. Two-eyed seeing and other lessons learned within a co-learning journey of bringing together Indigenous and mainstream knowledges and ways of knowing. *Journal of Environmental Studies and Sciences*, 2(4): 331–340. DOI: [10.1007/s10745-017-9919-0](https://doi.org/10.1007/s10745-017-9919-0)
- Berkes F. 2018. *Sacred ecology*. 4th ed. Routledge, New York, NY.
- Berrang-Ford L, Dingle K, Ford JD, Lee C, Lwasa S, Namanya DB, et al. 2012. Vulnerability of indigenous health to climate change: a case study of Uganda's Batwa pygmies. *Social Science and Medicine*, 75(6): 1067–1077. PMID: [22703884](https://pubmed.ncbi.nlm.nih.gov/22703884/) DOI: [10.1016/j.socscimed.2012.04.016](https://doi.org/10.1016/j.socscimed.2012.04.016)
- Berry HL, Butler JR, Burgess CP, King UG, Tsey K, Cadet-James YL, et al. 2010. Mind, body, spirit: Co-benefits for mental health from climate change adaptation and caring for country in remote Aboriginal Australian communities. *New South Wales Public Health Bulletin*, 21(6): 139–145. DOI: [10.1071/NB10030](https://doi.org/10.1071/NB10030)
- Binnema TT, and Niemi M. 2006. 'Let the line be drawn now': Wilderness, conservation, and the exclusion of aboriginal people from Banff National Park in Canada. *Environmental History*, 11(4): 724–750. DOI: [10.1093/envhis/11.4.724](https://doi.org/10.1093/envhis/11.4.724)
- Brinkman TJ, Hansen WD, Chapin FS, Kofinas G, BurnSilver S, and Rupp TS. 2016. Arctic communities perceive climate impacts on access as a critical challenge to availability of subsistence resources. *Climatic Change*, 139(3): 413–427. DOI: [10.1007/s10584-016-1819-6](https://doi.org/10.1007/s10584-016-1819-6)
- Brosi BJ, Balick MJ, Wolkow R, Lee R, Kostka M, Raynor W, et al. 2007. Cultural erosion and biodiversity: Canoe-making knowledge in Pohnpei, Micronesia. *Conservation Biology*, 21(3): 875–879. PMID: [17531064](https://pubmed.ncbi.nlm.nih.gov/17531064/) DOI: [10.1111/j.1523-1739.2007.00654.x](https://doi.org/10.1111/j.1523-1739.2007.00654.x)
- Bush E, and Lemmen DS. 2019. *Canada's changing climate report*. Government of Canada, Ottawa, ON. 444 p.
- Cajete G. 2018. Native science and sustaining Indigenous communities. In *Traditional ecological knowledge: Learning from Indigenous practices for environmental sustainability*. Edited by MK Nelson and D Shilling. Cambridge University Press, Cambridge, England. pp. 15–26.
- Cameron L, Courchene D, Ijaz S, and Mauro I. 2021. 'A change of heart': Indigenous perspectives from the Onjisay Aki Summit on climate change. *Climatic Change*, 164(3): 1–21.
- Chisolm Hatfield S, Marino E, Whyte KP, Dello KD, and Mote PW. 2018. Indian time: Time, seasonality, and culture in traditional ecological knowledge of climate change. *Ecological Processes*, 7: 25.

Cunsolo Willox A, Harper SL, Ford JD, Landman K, Houle K, and Edge VL. 2012. "From this place and of this place:" Climate change, sense of place, and health in Nunatsiavut, Canada. *Social Science and Medicine*, 75(3): 538–547. PMID: [22595069](#) DOI: [10.1016/j.socscimed.2012.03.043](#)

David-Chavez DM, and Gavin MC. 2018. A global assessment of Indigenous community engagement in climate research. *Environmental Research Letters*, 13(12): 123005. DOI: [10.1088/1748-9326/aaf300](#)

Delpla I, Jung AV, Baures E, Clement M, and Thomas O. 2009. Impacts of climate change on surface water quality in relation to drinking water production. *Environment International*, 35(8): 1225–1233. PMID: [19640587](#) DOI: [10.1016/j.envint.2009.07.001](#)

Derksen C, Burgess D, Duguay C, Howell S, Mudryk L, Smith S, et al. 2019. Changes in snow, ice, and permafrost across Canada. *In* Canada's changing climate report. Edited by E Bush and DS Lemmen. Government of Canada, Ottawa, Ontario. pp. 194–260.

Doiron M, Gauthier G, and Lévesque E. 2015. Trophic mismatch and its effects on the growth of young in an Arctic herbivore. *Global Change Biology*, 21(12): 4364–4376. PMID: [26235037](#) DOI: [10.1111/gcb.13057](#)

Eckert LE, Claxto NX, Owens C, Johnston A, Ban NC, Moola F, and Darimont CT. 2020. Indigenous knowledge and federal environmental assessments in Canada: Applying past lessons to the 2019 impact assessment act. *FACETS*, 5: 67–90. DOI: [10.1139/facets-2019-0039](#)

Ermine W. 2007. The ethical space of engagement. *Indigenous Law Journal*, 6(1): 193.

Ford JD. 2012. Indigenous health and climate change. *American Journal of Public Health*, 102(7): 1260–1266. DOI: [10.2105/AJPH.2012.300752](#) PMID: [22594718](#)

Ford JD, Cameron L, Rubis J, Maillet M, Nakashima D, Willox AC, and Pearce T. 2016. Including Indigenous knowledge and experience in IPCC assessment reports. *Nature Climate Change*, 6(4): 349–353. DOI: [10.1038/nclimate2954](#)

Ford JD, McDowell G, Shirley J, Pitre M, Siewierski R, Gough W, et al. 2013. The dynamic multiscale nature of climate change vulnerability: An Inuit harvesting example. *Annals of the Association of American Geographers*, 103: 1193–1211. DOI: [10.1080/00045608.2013.776880](#)

Friedl MA, Gray JM, Melaas EK, Richardson AD, Hufkens K, Keenan TF, Bailey A, and O'Keefe J. 2014. A tale of two springs: Using recent climate anomalies to characterize the sensitivity of temperate forest phenology to climate change. *Environmental Research Letters*, 9(5): 054006. DOI: [10.1088/1748-9326/9/5/054006](#)

Furberg M, Evengård B, and Nilsson M. 2011. Facing the limit of resilience: Perceptions of climate change among reindeer herding Sami in Sweden. *Global health action*, 4(1): 8417. DOI: [10.3402/gha.v4i0.8417](#)

Gagnon C, and Berteaux D. 2009. Integrating traditional ecological knowledge and ecological science: A question of scale. *Ecology and Society*, 14(2): 19. DOI: [10.5751/ES-02923-140219](#)

Gérin-Lajoie J, Herrmann TM, MacMillan GA, Hébert-Houle É, Monfette M, Rowell JA, et al. 2018. IMALIRIJIT: A community-based environmental monitoring program in the George River watershed, Nunavik, Canada. *Écoscience*, 25(4): 381–399.

Guyot M, Dickson C, Paci C, Furgal C, and Chan HM. 2006. Local observations of climate change and impacts on traditional food security in two northern Aboriginal communities. *International Journal of Circumpolar Health*, 65(5): 403–415. DOI: [10.3402/ijch.v65i5.18135](https://doi.org/10.3402/ijch.v65i5.18135) PMID: [17319085](https://pubmed.ncbi.nlm.nih.gov/17319085/)

Harper SL, Edge VL, Schuster-Wallace CJ, Berke O, and McEwen SA. 2011. Weather, water quality and infectious gastrointestinal illness in two Inuit communities in Nunatsiavut, Canada: Potential implications for climate change. *EcoHealth*, 8(1): 93–108. DOI: [10.1007/s10393-011-0690-1](https://doi.org/10.1007/s10393-011-0690-1) PMID: [21785890](https://pubmed.ncbi.nlm.nih.gov/21785890/)

Harrison K. 2020. Indigenous music sustainability during climate change. *Current Opinion in Environmental Sustainability*, 43: 28–34. DOI: [10.1016/j.cosust.2020.01.003](https://doi.org/10.1016/j.cosust.2020.01.003)

Hessami M, Bowles E, Popp J, and Ford AT. 2021. Reconciling the North American model of wildlife conservation with Indigenous-led conservation. *FACETS*, 6: 1285–1306.

Hovel RA, Brammer JR, Hodgson EE, Amos A, Lantz TC, Turner C, et al. 2020. The importance of continuous dialogue in community-based wildlife monitoring: Case studies of Dzan and Łuk Dagaii in the Gwich'in settlement area. *Arctic Science*, 6(3): 154–172. DOI: [10.1139/as-2019-0012](https://doi.org/10.1139/as-2019-0012)

Human Rights Watch (HRW). 2020. My fear is losing everything: The climate crisis and first Nations' Right to food in Canada. [online]: Available from [hrw.org/report/2020/10/21/my-fear-losing-everything/climate-crisis-and-first-nations-right-food-canada#_ftn30](https://www.hrw.org/report/2020/10/21/my-fear-losing-everything/climate-crisis-and-first-nations-right-food-canada#_ftn30).

Intergovernmental Panel on Climate Change (IPCC). 2014. Climate change 2014 – impacts, adaptation, and vulnerability: Part A: Global and sectoral aspects: Working Group II contribution to the IPCC Fifth Assessment Report. Cambridge University Press, Cambridge. DOI: [10.1017/cbo9781107415379](https://doi.org/10.1017/cbo9781107415379)

Jacob C, McDaniels T, and Hinch S. 2010. Indigenous culture and adaptation to climate change: Sockeye Salmon and the St'át'imc People. *Mitigation and Adaptation Strategies for Global Change*, 15(8): 859–876. DOI: [10.1007/s11027-010-9244-z](https://doi.org/10.1007/s11027-010-9244-z)

Kimmerer R. 1998. Intellectual diversity: Bringing the native perspective into natural resources education. *Winds of Change*, 13: 14–18.

Kimmerer RW. 2018. Mishkos Kenomagwen, the lessons of grass: Restoring reciprocity with the Good Green Earth. In *Traditional ecological knowledge: Learning from Indigenous practices for environmental sustainability*. Edited by MK Nelson and D Shilling. Cambridge University Press, Cambridge, England. pp. 27–56.

Kouril D, Furgal C, and Whillans T. 2016. Trends and key elements in community-based monitoring: A systematic review of the literature with an emphasis on Arctic and Subarctic regions. *Environmental Reviews*, 24(2): 151–163. DOI: [10.1139/er-2015-0041](https://doi.org/10.1139/er-2015-0041)

Kral MJ, Idlout L, Minore JB, Dyck RJ, and Kirmayer LJ. 2011. Unikkaartuit: Meanings of well-being, unhappiness, health, and community change among Inuit in Nunavut, Canada. *American Journal of Community Psychology*, 48(3–4): 426–438. PMID: [21387118](https://pubmed.ncbi.nlm.nih.gov/21387118/) DOI: [10.1007/s10464-011-9431-4](https://doi.org/10.1007/s10464-011-9431-4)

Laidler GJ, Ford JD, Gough WA, Ikummaq T, Gagnon AS, Kowal S, Qrunnut K, and Irngaut C. 2009. Travelling and hunting in a changing Arctic: Assessing Inuit vulnerability to sea ice change in Igloodik, Nunavut. *Climatic Change*, 94(3–4): 363–397. DOI: [10.1007/s10584-008-9512-z](https://doi.org/10.1007/s10584-008-9512-z)

- Lameris TK, van der Jeugd HP, Eichhorn G, Dokter AM, Bouten W, Boom MP, et al. 2018. Arctic geese tune migration to a warming climate but still suffer from a phenological mismatch. *Current Biology*, 28(15): 2467–2473.e4. PMID: [30033332](#) DOI: [10.1016/j.cub.2018.05.077](#)
- Latulippe N. 2015. Bridging parallel rows: Epistemic difference and relational accountability in cross-cultural research. *International Indigenous Policy Journal*, 6(2). DOI: [10.18584/iipj.2015.6.2.7](#)
- Latulippe N, and Klenk N. 2020. Making room and moving over: Knowledge co-production, Indigenous knowledge sovereignty and the politics of global environmental change decision-making. *Current Opinion in Environmental Sustainability*, 42: 7–14. DOI: [10.1016/j.cosust.2019.10.010](#)
- Le Corre M, Dussault C, and Côté SD. 2017. Weather conditions and variation in timing of spring and fall migrations of migratory caribou. *Journal of Mammalogy*, 98(1): 260–271.
- Lindenmayer DB, Burns EL, Tennant P, Dickman CR, Green PT, Keith DA, et al. 2015. Contemplating the future: Acting now on long-term monitoring to answer 2050's questions. *Austral Ecology*, 40(3): 213–224. DOI: [10.1111/aec.12207](#)
- Lynn K, Daigle J, Hoffman J, Lake F, Michelle N, Ranco D, et al. 2013. The impacts of climate change on tribal traditional foods. *Climatic Change*. DOI: [10.1007/s10584-013-0736-1](#)
- Makondo CC, and Thomas DS. 2018. Climate change adaptation: Linking Indigenous knowledge with western science for effective adaptation. *Environmental Science and Policy*, 88: 83–91. DOI: [10.1016/j.envsci.2018.06.014](#)
- Martinez D. 2018. Redefining sustainability through kincentric ecology: Reclaiming Indigenous lands, knowledge, and ethics. In *Traditional ecological knowledge: Learning from Indigenous practices for environmental sustainability*. Edited by MK Nelson, and D Shilling. Cambridge University Press, Cambridge, England. pp. 137–174.
- Matthews HD, Graham TL, Keverian S, Lamontagne C, Seto D, and Smith TJ. 2014. National contributions to observed global warming. *Environmental Research Letters*, 9(1): 014010. DOI: [10.1088/1748-9326/9/1/014010](#)
- Mattoo A, and Subramanian A. 2012. Equity in climate change: An analytical review. *World Development*, 40(6): 1083–1097. DOI: [10.1016/j.worlddev.2011.11.007](#)
- McGregor D. 2002. Traditional ecological knowledge and the Two-Row Wampum. *Biodiversity*, 3(3): 8–9. DOI: [10.1080/14888386.2002.9712586](#)
- McGregor D. 2004. Coming full circle: Indigenous knowledge, environment, and our future. *American Indian Quarterly*, 28(3): 385–410. DOI: [10.1353/aiq.2004.0101](#)
- McGregor D. 2018. *Mino-Mnaamodzawin*: Achieving Indigenous environmental justice in Canada. *Environment and Society: Advances in Research*, 9: 7–24.
- Meehan K, Jepson W, Harris LM, Wutich A, Beresford M, Fencel A, et al. 2020. Exposing the myths of household water insecurity in the global North: A critical review. *Wiley Interdisciplinary Reviews: Water*, 7(6): e1486.
- Menzel A, and Fabian P. 1999. Growing season extended in Europe. *Nature*, 397(6721): 659–659. DOI: [10.1038/17709](#)

- Michell HJ. 2011. Working with Elders and Indigenous knowledge systems: A reader and guide for places of higher learning. J Carlton Publishing, Vernon, BC, Canada.
- Middleton J, Cunsolo A, Jones-Bitton A, Wright CJ, and Harper SL. 2020. Indigenous mental health in a changing climate: A systematic scoping review of the global literature. *Environmental Research Letters*, 15(5): 053001. DOI: [10.1088/1748-9326/ab68a9](https://doi.org/10.1088/1748-9326/ab68a9)
- Mikraszewicz K, and Richmond C. 2019. Paddling the *Biigtig: Mino biimadisiwin* practiced through canoeing. *Social Science and Medicine*, 240: 112548. PMID: [31563762](https://pubmed.ncbi.nlm.nih.gov/31563762/) DOI: [10.1016/j.socscimed.2019.112548](https://doi.org/10.1016/j.socscimed.2019.112548)
- Moerlein KJ, and Carothers C. 2012. Total environment of change: Impacts of climate change and social transitions on subsistence fisheries in northwest Alaska. *Ecology and Society*, 17(1). DOI: [10.5751/ES-04543-170110](https://doi.org/10.5751/ES-04543-170110)
- Murphy-Klassen HM, Underwood TJ, Sealy SG, and Czyrnyj AA. 2005. Long-term trends in spring arrival dates of migrant birds at Delta Marsh, Manitoba, in relation to climate change. *The Auk*, 122(4): 1130–1148. DOI: [10.1093/auk/122.4.1130](https://doi.org/10.1093/auk/122.4.1130)
- National Inquiry into Missing and Murdered Indigenous Women and Girls (NIMMIWG). 2019. Reclaiming power and place: The final report of the national inquiry into missing and murdered indigenous women and girls. Volume 1a. 722 p. [online]: Available from mmiwg-ffada.ca/final-report/.
- Nelson MK, and Shilling D. 2018. Traditional ecological knowledge: Learning from Indigenous practices for environmental sustainability. Cambridge University Press, Cambridge, England. 276 p.
- Noyes PD, McElwee MK, Miller HD, Clark BW, Van Tiem LA, Walcott KC, Erwin KN, and Levin ED. 2009. The toxicology of climate change: Environmental contaminants in a warming world. *Environment international*, 35(6): 971–986. PMID: [19375165](https://pubmed.ncbi.nlm.nih.gov/19375165/) DOI: [10.1016/j.envint.2009.02.006](https://doi.org/10.1016/j.envint.2009.02.006)
- Pankhurst NW, and Munday PL. 2011. Effects of climate change on fish reproduction and early life history stages. *Marine and Freshwater Research*, 62(9): 1015–1026. DOI: [10.1071/MF10269](https://doi.org/10.1071/MF10269)
- Parlee B, and Berkes F. 2005. Health of the land, health of the people: A case study on Gwich'in berry harvesting in northern Canada. *EcoHealth*, 2(2): 127–137. DOI: [10.1007/s10393-005-3870-z](https://doi.org/10.1007/s10393-005-3870-z)
- Peers MJ, Majchrzak YN, Menzies AK, Studd EK, Bastille-Rousseau G, Boonstra R, et al. 2020. Climate change increases predation risk for a keystone species of the boreal forest. *Nature Climate Change*, 10(12): 1149–1153. DOI: [10.1038/s41558-020-00908-4](https://doi.org/10.1038/s41558-020-00908-4)
- Perry AL, Low PJ, Ellis JR, and Reynolds JD. 2005. Climate change and distribution shifts in marine fishes. *Science*, 308(5730): 1912–1915. PMID: [15890845](https://pubmed.ncbi.nlm.nih.gov/15890845/) DOI: [10.1126/science.1111322](https://doi.org/10.1126/science.1111322)
- Pierotti R, and Wildcat D. 2000. Traditional ecological knowledge: The third alternative. *Ecological Applications* 10: 1333–1340. DOI: [10.1890/1051-0761\(2000\)010\[1333:TEKTTA\]2.0.CO;2](https://doi.org/10.1890/1051-0761(2000)010[1333:TEKTTA]2.0.CO;2)
- Popp JN, Priadka P, Young M, Koch K, and Morgan J. 2020. Indigenous guardianship and moose (*Alces alces*): Weaving indigenous and western approaches. *Human-Wildlife Interactions*, 14: 296–308.

- Proverbs TA, Stewart AR, Vittrekwa A, Vittrekwa E, Hovel RA, and Hodgson EE. 2021. Disrupted ecosystem and human phenology at the climate frontline in Gwich'in First Nation territory. *Conservation Biology*, 35(4): 1348.
- Reed G, Brunet ND, Longboat D, and Natcher DC. 2021. Indigenous guardians as an emerging approach to indigenous environmental governance. *Conservation Biology*, 35(1): 179–189.
- Reid AJ, Eckert LE, Lane JF, Young N, Hinch SG, Darimont CT, et al. 2020. “Two-Eyed Seeing”: An Indigenous framework to transform fisheries research and management. *Fish and Fisheries*, 22: 243–261. DOI: [10.1111/faf.12516](https://doi.org/10.1111/faf.12516)
- Reo NJ, and Parker AK. 2013. Re-thinking colonialism to prepare for the impacts of rapid environmental change. *Climatic Change*, 120(3): 671–682. DOI: [10.1007/s10584-013-0783-7](https://doi.org/10.1007/s10584-013-0783-7)
- Richmond C, Elliott SJ, Matthews R, and Elliott B. 2005. The political ecology of health: Perceptions of environment, economy, health and well-being among ‘Namgis First Nation. *Health & Place*, 11(4): 349–365. PMID: [15886143](https://pubmed.ncbi.nlm.nih.gov/15886143/) DOI: [10.1016/j.healthplace.2004.04.003](https://doi.org/10.1016/j.healthplace.2004.04.003)
- Sakakibara C. 2009. ‘No whale, no music’: Iñupiaq drumming and global warming. *The Polar Record*, 45(4): 289. DOI: [10.1017/S0032247408008164](https://doi.org/10.1017/S0032247408008164)
- Settee P, and Shukla S. 2020. Indigenous food systems: Concepts, cases, and conversations. Canadian Scholars, Toronto, Canada.
- Simpson L. 2000. Anishinaabe ways of knowing. In *Aboriginal health, identity and resources*. Edited by J Oakes, R Riew, S Koolage, L Simpson, and N Schuster. Native Studies Press, Routledge Publishing, London, England. pp. 165–185.
- Steltzer H, and Post E. 2009. Seasons and life cycles. *Science*, 324(5929): 886–887. PMID: [19443769](https://pubmed.ncbi.nlm.nih.gov/19443769/) DOI: [10.1126/science.1171542](https://doi.org/10.1126/science.1171542)
- Tachine AR, Bird EY, and Cabrera NL. 2016. Sharing circles: An Indigenous methodological approach for researching with groups of Indigenous peoples. *International Review of Qualitative Research*, 9(3): 277–295. DOI: [10.1525/irqr.2016.9.3.277](https://doi.org/10.1525/irqr.2016.9.3.277)
- Tam BY, Gough WA, Edwards V, and Tsuji LJ. 2013. The impact of climate change on the well-being and lifestyle of a First Nation community in the western James Bay region. *The Canadian Geographer/Le Géographe Canadien*, 57(4): 441–456. DOI: [10.1111/j.1541-0064.2013.12033.x](https://doi.org/10.1111/j.1541-0064.2013.12033.x)
- Thackeray SJ, Henrys PA, Hemming D, Bell JR, Botham MS, Burthe S, et al. 2016. Phenological sensitivity to climate across taxa and trophic levels. *Nature*, 535(7611): 241–245. PMID: [27362222](https://pubmed.ncbi.nlm.nih.gov/27362222/) DOI: [10.1038/nature18608](https://doi.org/10.1038/nature18608)
- The Truth and Reconciliation Commission of Canada (TRC). 2015. Honouring the truth, reconciling for the future: Summary of the final report of the Truth and Reconciliation Commission of Canada. pp 535. [online]: Available from nctr.ca/records/reports/.
- Thompson KL, Reece N, Robinson N, Fisher HJ, Ban NC, and Picard CR. 2019. “We monitor by living here”: Community-driven actualization of a social-ecological monitoring program based in the knowledge of Indigenous harvesters. *FACETS*, 4(1): 293–314. DOI: [10.1139/facets-2019-0006](https://doi.org/10.1139/facets-2019-0006)

Timoti P, Jones CJ, Richardson SJ, Tahi BL, and Greenhalgh S. 2017. An Indigenous community-based monitoring system for assessing forest health in New Zealand. *Biodiversity and Conservation*, 26(13): 3183–3212. DOI: [10.1007/s10531-016-1142-6](https://doi.org/10.1007/s10531-016-1142-6)

Todd BD, Scott DE, Pechmann JH, and Gibbons JW. 2011. Climate change correlates with rapid delays and advancements in reproductive timing in an amphibian community. *Proceedings of the Royal Society B: Biological Sciences*, 278(1715): 2191–2197.

Tsosie R. 2007. Indigenous people and environmental justice: The impact of climate change. *University of Colorado Law Review*, 78: 1625–1678.

Turner NJ, and Clifton H. 2009. “It’s so different today”: Climate change and Indigenous lifeways in British Columbia, Canada. *Global Environmental Change*, 19: 180–190. DOI: [10.1016/j.gloenvcha.2009.01.005](https://doi.org/10.1016/j.gloenvcha.2009.01.005)

Whyte K. 2017. Indigenous climate change studies: Indigenizing futures, decolonizing the Anthropocene. *English Language Notes*, 55: 153–162. DOI: [10.1215/00138282-55.1-2.153](https://doi.org/10.1215/00138282-55.1-2.153)

Whyte K. 2018. What do Indigenous Knowledges do for Indigenous Peoples? In *Traditional ecological knowledge: Learning from Indigenous practices for environmental sustainability*. Edited by MK Nelson, and D Shilling. Cambridge University Press, Cambridge, England, pp. 57–82.

Willox AC, Stephenson E, Allen J, Bourque F, Drossos A, Elgarøy S, et al. 2015. Examining relationships between climate change and mental health in the Circumpolar North. *Regional Environmental Change*, 15(1): 169–182. DOI: [10.1007/s10113-014-0630-z](https://doi.org/10.1007/s10113-014-0630-z)

Wilson K. 2003. Therapeutic landscapes and First Nations peoples: An exploration of culture, health and place. *Health and Place*, 9: 83–93. PMID: [12753791](https://pubmed.ncbi.nlm.nih.gov/12753791/) DOI: [10.1016/S1353-8292\(02\)00016-3](https://doi.org/10.1016/S1353-8292(02)00016-3)

Wilson NJ, Mutter E, Inkster J, and Satterfield T. 2018. Community-based monitoring as the practice of Indigenous governance: A case study of Indigenous-led water quality monitoring in the Yukon River Basin. *Journal of Environmental Management*, 210: 290–298. PMID: [29407189](https://pubmed.ncbi.nlm.nih.gov/29407189/) DOI: [10.1016/j.jenvman.2018.01.020](https://doi.org/10.1016/j.jenvman.2018.01.020)

Wong C, Ballegooyen K, Ignace L, Johnson MJ, and Swanson H. Towards reconciliation: 10 calls to action to natural scientists working in Canada. *FACETS*, 5(1): 769–783. DOI: [10.1139/facets-2020-0005](https://doi.org/10.1139/facets-2020-0005)