

Towards reconciliation: 10 Calls to Action to natural scientists working in Canada

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Abstract

In 2015, after documenting testimonies from Indigenous survivors of the residential school system in Canada, the Truth and Reconciliation Commission released 94 Calls to Action to enable reconciliation between Indigenous and non-Indigenous Canadians. Without personal connections to Indigenous communities, many Canadians fail to grasp the depth of intergenerational impacts of residential schools and associated systemic racism. Consequently, reconciliation remains an elusive concept. Here we outline 10 Calls to Action to natural scientists to enable reconciliation in their work. We focus on natural scientists because a common connection to the land should tie the social license of natural scientists more closely to Indigenous communities than currently exists. We also focus on natural sciences because of the underrepresentation of Indigenous peoples in this field. We draw on existing guidelines and our experiences in northern Canada. Our 10 Calls to Action are triggered by frustration. The authors have witnessed examples where natural scientists treat Indigenous communities with blatant disrespect or with ignorance of Indigenous rights. These 10 Calls to Action challenge the scientific community to recognize that reconciliation requires a new way of conducting natural science, one that includes and respects Indigenous communities, rights, and knowledge leading to better scientific and community outcomes.

Key words: reconciliation, social license to conduct science, Indigenous Knowledge, research ethics for natural sciences, Indigenous self-determination in research, Indigenous science, decolonizing research

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Introduction

In 2015, the Truth and Reconciliation Commission (TRC) released 94 Calls to Action to redress the intergenerational legacy of, and the systemic racism behind, residential schools in Canada ([Truth and Reconciliation Commission of Canada 2015b](#)). Over 150 000 Indigenous (First Nation, Métis, and Inuit) children attended these schools, which operated for over 150 years as tools of cultural assimilation by the Canadian government ([Truth and Reconciliation Commission of Canada 2015a](#)). The Calls to Action were developed to facilitate and enable reconciliation, rebalance relationships between Indigenous and non-Indigenous Canadians, to tell this part of Canadian history, and to create a path forward based on mutual respect. The TRC stated that “virtually all aspects of Canadian society may need to be reconsidered” for true reconciliation with Indigenous

peoples. The majority of the 94 Calls to Action by the TRC are aimed at governments and institutions and not at the level of individuals. Factual Indigenous history, including the history of residential schools in Canada, is a recent addition to public education in Canada. As a result, most non-Indigenous adults have received no education concerning Indigenous history or the legacy of residential schools. Without personal connections to Indigenous communities, colleagues, or friends, many Canadians fail to grasp the residual injustice and racism in Canada or the depth of intergenerational trauma and other impacts of residential schools (Truth and Reconciliation Commission of Canada 2015c). Consequently, understanding how to enable reconciliation at the level of individual Canadians remains an elusive concept. In this paper, we outline 10 Calls to Action to natural scientists to enable reconciliation. We hope these calls will spark initiative and engagement and help natural scientists build a foundation of mutual respect and understanding with Indigenous peoples that allows for direct reconciliatory actions.

Scientific research is not immune to or removed from the need for reconciliation (Kovach 2009; McGregor 2018). Indigenous communities distrust researchers from all disciplines because of past exploitations, which include treatment of Indigenous peoples as research subjects without consent, misuse of health data, theft of cultural resources, and manipulation of wildlife (Kovach 2009; Mosby 2013; Inuit Tapiriit Kanatami 2018). Reconciliation is required to rebuild trust and respect. We focus on natural scientists because of the strong connections between Indigenous peoples and the land (Berkes 2017; Ban et al. 2018). Natural scientists and Indigenous communities alike are interested in understanding patterns at the level of landscapes and, more recently, how landscapes are changing with human influences, most notably climate change (Krupnik and Jolly 2002; Alexander et al. 2011; Johnson et al. 2016). We argue this shared connection to the land should tie natural scientists' social license to conduct research more closely to Indigenous communities than currently exists. Social license is the informal acceptance of the research and expectations of its benefits by the community and the public at large (Moffat et al. 2016).

Social and health scientists in Canada have been guided for years on the ethical conduct for research involving humans by a policy which was jointly issued by the three federal research agencies in Canada—the Tri-Council: Social Sciences and Humanities Research Council (SSHRC), Canadian Institutes of Health Research (CIHR), and Natural Sciences and Engineering Research Council (NSERC). The Tri-Council's Policy Statement on the Ethical Conduct for Research Involving Humans (TCPS 2) has a chapter on working with Indigenous communities (Canadian Institutes of Health Research et al. 2018). Although NSERC is part of the Tri-Council, we argue that very few natural science researchers are aware of the guidance given by TCPS 2 on working with Indigenous communities. It would appear most natural scientists do not see the link between their work and Indigenous communities if people are not directly interviewed or sampled.

We also focus on natural sciences because of the underrepresentation of Indigenous peoples in natural science fields. Indigenous people in Canada are less likely to obtain STEM (science, technology, engineering, and mathematics and computer science) degrees than non-Indigenous Canadians. Only 0.9% of the Indigenous population older than 15 years hold a bachelor's STEM degree ($n = 10\,770$) and 0.2% hold a graduate STEM degree ($n = 2845$) (Statistics Canada 2016). Non-Indigenous education attainment rates for these degrees are four and 10 times higher (4.0% and 2.0% respectively). Relatively more Indigenous people hold degrees in business, humanities, health arts, social science, and education fields: 5.5% hold bachelor's degrees and 2.0% hold graduate degrees. Under-representation in the natural sciences means it is challenging for Indigenous perspectives to influence scientific processes and endeavours, including decisions on educational content, research ethics, research methods, and funding.

More disconcerting is the large gap in attaining literacy in mathematics and science in grade school between Indigenous and non-Indigenous students across Canada. For example, only 44% of First Nation students in Grade 7 in Yukon met numeracy expectations compared with 77% of non-First Nations students in 2017–2018 ([Auditor General of Canada 2019](#)). Similarly, attainment of grade 12 standardized math was 54% for Indigenous students versus 70% of non-Indigenous students in Manitoba in 2013–2014 ([Auditor General of Manitoba 2016](#)). In British Columbia, only 46% of Indigenous students in Grade 10 science do better than C+, in contrast to 70% of non-Indigenous students in 2015–2016 ([British Columbia Ministry of Education 2019](#)). Natural scientists can play an influential role in addressing the gap in scientific literacy between Indigenous and non-Indigenous students.

We were motivated by the Truth and Reconciliation Committee to translate the general intent of relevant Calls to Action into tangible outcomes and approaches that can be employed by natural scientists. We drew on existing guidelines on ethical conduct for research involving humans, cultural resources, and data ownership. These include: United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP; [United Nations General Assembly 2007](#)), First Nation principles of OCAP® (Ownership, Control, Access and Possession, [The First Nations Information Governance Centre 2014](#))¹, National Inuit Strategy on Research ([Inuit Tapiriit Kanatami 2018](#)), Principles for Ethical Métis Research ([National Aboriginal Health Organization 2011](#)), guidelines for conducting research in northern Canada ([Association of Canadian Universities for Northern Studies 2003](#); [Aurora Research Institute 2019](#)), TCSP 2, and perspectives on reconciliation from social scientists and other initiatives.

We also draw upon our experiences from working on the ground with natural scientists. The authors of this paper include: (i) MJJ, an Elder from Kluane First Nation who has worked for decades documenting Indigenous cultural resources for Kluane First Nation and the federal government; (ii) LL, a policy analyst who is Anishinaabe and worked for The Assembly of First Nations on species at risk and Indigenous Knowledge; (iii) HS, a professor at University of Waterloo specializing in freshwater toxicology who has worked across northern Canada; (iv) KB, the Resource Manager for Kluane First Nation; and (v) CW, the ecologist for Kluane National Park and Reserve, Yukon. Three of the authors review applications for research permits in Yukon and Kluane National Park and Reserve, which is cooperatively managed by Parks Canada, Kluane First Nation, and Champagne and Aishihik First Nations.

These Calls to Action are triggered by frustration. The authors have all witnessed examples where natural scientists treat Indigenous communities with blatant disrespect or with profound ignorance of Indigenous rights without realizing how much research can benefit from an Indigenous perspective. Although our experiences are primarily limited to Yukon, colleagues in other jurisdictions in Canada have shared incidents similar to what we describe in this paper. First Nation and Inuit organizations and governments in the northern territories are ahead of most other areas of Canada in terms of asserting self-determination over research. In Yukon, Final Agreements are in place for 11 of the 14 First Nations with traditional territories covering most of the land area. If you are conducting natural science research in Yukon, you will more than likely be dealing with a First Nation government with constitutionally protected rights and law-making over their lands and interests. Furthermore, Inuit Nunangat covers approximately 35% of Canada's land mass ([Inuit Tapiriit Kanatami 2018](#)), and there are 634 First Nation communities and over 587 000 Métis found across Canada ([Statistics Canada 2017](#)). As a result, the reality of conducting research on land somewhere of interest to Indigenous peoples is almost guaranteed in Canada.

¹OCAP® is a registered trademark of the First Nations Information Governance Centre (FNIGC) ([FNIGC.ca/OCAP/h](https://fnigc.ca/OCAP/h)).

Calls to Action to natural scientists working in Canada

Call 1: We call on natural scientists to understand the socio-political landscape around their research sites.

Indigenous peoples have the right to self-determination as per Article 3 of UNDRIP ([United Nations General Assembly 2007](#)). We all have a moral obligation to understand how Indigenous peoples are manifesting or attempting to express these rights in our everyday lives and activities. This includes the arena of research. Over the last several hundred years, Indigenous peoples have continued to push for the type of relationship and moral space they wish to attain within the Canadian context. Now, there are constitutionally recognized rights, titles, treaties, and land claim agreements across Canada. These are clear expressions of Indigenous peoples' right to self-determination. Engaging with Indigenous peoples in all types of research will support Indigenous peoples' self-determination and their attempts to restructure the relationship within Canada ([Yukon Indian People 1977](#)).

Indigenous peoples also have the right to determine priorities and strategies for the use or development of their lands (Article 32.1 of UNDRIP). Article 32.2 goes further to state that "States shall consult and cooperate in good faith with Indigenous peoples in order to obtain their free and informed consent prior to the approval of any project affecting their lands or territories and other resources". Although Article 32.2 is directed at governments, individual researchers, especially those receiving public funds, should consider their obligation to consult and co-operate with Indigenous communities to obtain their consent. Direct application of the intent of these UNDRIP Articles to research can be found in the National Inuit Strategy on Research ([Inuit Tapiriit Kanatami 2018](#)).

The first step to better understand how proposed research initiatives may impact Indigenous peoples is to determine which Indigenous government or community has jurisdiction over or interests in the research site. Many Indigenous communities have their own ethics guidelines for research and (or) process for research permitting. Natural scientists should be aware of local requirements. The next step is to determine who to talk to and to genuinely engage with them on what is being proposed and how the proposal meets the interest and priorities of Indigenous communities. This is often complicated as there can be multiple overlapping traditional territories and complex authority structures within an Indigenous government or community. It takes time and effort to understand the socio-political landscape around a research site.

The consequences of not understanding the socio-political landscape can result in the obstruction of research from proceeding. For example, in 2013, Champagne and Aishihik First Nations invoked a stop-work order with the Yukon Supreme Court on archaeological research in ice patches that had been permitted by Yukon government, despite the First Nations opposing the original permit application ([Grabowski 2017](#)). The research eventually proceeded in partnership with Champagne and Aishihik First Nations.

Call 2: We call on natural scientists to recognize that generating knowledge about the land is a goal shared with Indigenous peoples and to seek meaningful relationships and possible collaboration for better outcomes for all involved.

The common ground between Indigenous communities and scientists might be an understanding that we are all part of something greater than our differences ([Bouvier 2013](#)) and that complex problems can benefit from multiple ways of knowing. Indigenous peoples inhabiting areas since time immemorial have developed an exceptional understanding of the environment needed for their survival ([Krupnik and Jolly 2002](#)). From their communal memory, Indigenous peoples are capable

of observing trends or variations in their lands that no other sensor can replicate (Alessa et al. 2016). Because Indigenous peoples have deep understanding of the land and continue to require new information to adapt to impacts from climate change, early engagement with Indigenous communities can determine shared questions with scientists and explore where the two different knowledge systems (Indigenous and Western) may complement each other or can be bridged. Early dialogue can result in a stronger framework of hypotheses to test (Ban et al. 2018).

Reconciliation requires exploring opportunities for reciprocity such that both the Indigenous community and the natural scientist benefit from publicly funded research (Inuit Tapiriit Kanatami 2018; McGregor 2018). While relationships and collaborations with Indigenous communities will vary depending on the nature and length of the work and community capacity, they must always be built on a strong foundation of respect for Indigenous rights, guidelines, protocols, customs, and respect for the land on which the work is occurring (Adams et al. 2014). Researchers will be better received when they present themselves to communities as people first and recognize that professional credentials are often not valued as much as humility, honesty, and a willingness to listen, adapt, and respond. Awareness of previous experiences (both positive and negative) that a community has had with previous researchers is often instrumental in the development of new relationships. While community questions and scientific questions may not align, there are multiple ways scientists can facilitate reciprocity without impacting academic freedom, e.g., offering technical expertise to address the community's research needs or offering field positions as educational and economic opportunities. Provision of employment and training opportunities should be developed in collaboration with the community and extend beyond permitting requirements whenever possible. One common example in the Arctic is to hire Bear Monitors whose job is to monitor polar bears to provide safety during field work.

In our experience, when scientists engage communities early enough, the quality of scientific and community outcomes is higher, the process is less likely to become adversarial, and the researcher is more likely to generate creative solutions to concerns raised. Early dialogue allows researchers to constructively consider and integrate community priorities into applications for funding and permits, and results in refinement of research questions, methods, outcomes, and deliverables such that the community is better served and respected. When a call for proposals occurs on very tight timelines, as is increasingly the case, the researcher should anticipate that achieving meaningful community engagement may not be possible and efforts may have to be redirected to the next funding cycle.

Developing relationships with Indigenous communities can be very daunting to young scientists and (or) those who are not trained or experienced with working in cross-cultural environments (MacMillan et al. 2019). Engaging a mentor who has an established track record of successful partnerships with Indigenous communities, consulting other scientists who have worked in the community or region, and following other advice in Tondou et al. (2014) can help facilitate a positive outcome and experience for all. In some communities, liaisons can be hired to ensure researchers enter into dialogue and undertake their work with appropriate context. Liaisons can also facilitate ongoing effective communication—this can be especially helpful in remote communities—and can assist with administration of local employment opportunities associated with the research. Although it is difficult to overstate the value of face-to-face meetings in fostering relationships, sensitivity to available capacity and technology is appreciated; we suggest that researchers ask for feedback on how often and what means of communication are preferred.

Call 3: We call on natural scientists to enable knowledge sharing and knowledge co-production.

Reconciliation is about restoring balance in the relationship between Indigenous peoples and non-Indigenous Canadians (McGregor 2018). It involves a shift in power and knowledge, that is, who holds the knowledge and who decides what type of knowledge is recognized as valid (Nadasdy 2003). Natural scientists hold and generate a vast amount of knowledge related to the land. However, in our experience, this typically only gets shared with Indigenous communities through indigestible scientific journal articles, if shared at all. Better understanding of the land is more likely when research is conducted in a respectful and inclusive manner, taking into account both Indigenous and Western knowledge systems (Nadasdy 2003; Ban et al. 2018). This is particularly important as comanagement arrangements around natural resources increase. Meaningful knowledge sharing and knowledge coproduction results in better understanding and management of resource activities on the land (Berkes 2009).

To enable knowledge sharing, we emphasize the importance for scientists to demonstrate respect and to create the time and space to listen to the Indigenous community and their information needs. Summaries of research should be designed to be accessible by an Indigenous community, which may require paying for translation into an Indigenous language. Wider audiences, particularly youth, could be reached through creative mediums such as social media, video, or audio instead of formal scientific presentations. Also, communities may require additional work to bridge or translate scientific results to inform environmental assessments or other management decisions involving the land (Berkes 2009). Research deliverables and funding requirements from institutions should include opportunities to share results with the community and time for review by the community.

As part of Kluane First Nation's development of its own research strategy, it organized two research summits between researchers and community members to enable the sharing of not only research results but also community concerns in their traditional territory. There are similar examples of knowledge-sharing workshops in other northern regions in Canada (e.g., Mushkegowuk Climate Summit in the Hudson and James Bay area and the Beluga Summit in Inuvik (Loseto et al. 2018)). The *Lhù'ààn Mân'* (Kluane Lake) Research Summit asked participants to commit to doing just one thing for the community that could increase knowledge sharing. The resulting commitments included involving youth in field work, writing digestible one-page summaries explaining their research, compiling a list of research they had done in the traditional territory, and formatting it in a way that was helpful to the community. We call upon all researchers to make existing knowledge, data, and information more accessible to communities. This includes past research projects and commitments to repatriating data from governments, researchers, and institutions to the respective communities.

Knowledge coproduction can occur when Indigenous communities and scientists come together to generate new knowledge or to synergize information from different sources to address a question (Davidson-Hunt and O'Flaherty 2007). It can change power dynamics such that knowledge holders are both Indigenous peoples and scientists (Berkes 2009; Armitage et al. 2011). Knowledge coproduction respects and includes both Indigenous and Western knowledge systems. Respect for Indigenous Knowledge includes understanding that Indigenous peoples have inherent rights and jurisdiction over Indigenous Knowledge as well as research and information collected by and about their people, and on their traditional territories (OCAP®; The First Nations Information Governance Centre 2014; Inuit Tapiriit Kanatami 2018). Many Indigenous communities have protocols guiding use of Indigenous Knowledge. One compilation of resources can be found within the guidelines for using Indigenous Knowledge when assessing species at risk (Committee on the Status of Endangered Wildlife in Canada 2010). Knowledge coproduction is a larger endeavor than knowledge sharing but both require a commitment to sharing knowledge in a meaningful way. Knowledge coproduction

could involve coauthorship, both at the publication stage and at the project development and interim reporting stages, for example, at conference presentations. Conferences have a more flexible format for respecting and communicating Indigenous Knowledge. However, it is important to acknowledge that successful knowledge transfer for an Indigenous community is not measured in the number of scientific journal publications as it is in academia. MJJ, Kluane First Nation Elder, emphasizes that knowledge sharing and coproduction is ultimately a success if the knowledge generated becomes part of the oral history of the Indigenous community.

Call 4: We call on natural scientists studying animals to seek out advice from Elders for respectful ways of handling animals

Research on animals in Canada requires demonstration of humane practices and approval from an Animal Ethics Committee housed within Universities or governments. While Indigenous worldviews align with that of not doing undue cruelty to animals, there is often much more required in specific, local customs to demonstrate respect to animals and the land. There are Indigenous protocols to follow to demonstrate stewardship for the land—scientific research should also follow these protocols (Whyte et al. 2016). Seeking out information on these protocols will help natural scientists obtain the trust and social license for their research with Indigenous communities. For example, in southern Yukon, the concept of *düli*, guides how to behave on the land. CW learned of this concept when she proposed to swab frogs for chytrid fungus to monitor the health of the local frog populations. MJJ, her colleague and an Elder, warned CW that anything that happens to a frog will happen to her, explaining that frogs were very significant and highly valued by many First Nations. Learning about *düli* had a profound influence on how CW as a western scientist now approaches research questions. She looks to Elders and *düli* to guide the selection of research method, i.e., asking if there are alternate methods that are less intrusive for gaining the same information. In the case of frog health, monitoring now uses the least intrusive method of call surveys where frogs are not handled. Swabbing for disease will only be used if there are warranted indications of a declining population and with the guidance of Elders.

Seeking out the advice of Elders can be daunting for young scientists and those without pre-established relationships in the Indigenous communities. We see two scales of options for improving this element. One is at the institutional level where natural scientists could advocate for the need for advisory bodies of Elders to guide Animal Ethic Committees at universities. An example of such an advisory body was piloted with the Canadian Mountain Network, with the establishment of the Indigenous Circle of Advisors with multiple representatives across Canada to review research proposals. The other option is at the local level of communities. Most First Nations have an Elders Council where researchers could ask to present their proposals and seek direction on how to do research in the respective traditional territory. Most often gaining an audience with the Elders' Councils requires time in the community and effort in relationship building.

Instituting an Indigenous Circle of Advisors would mitigate situations when requirements set out by institutional Animal Ethics Committees are in direct conflict with respect of Indigenous rights, customs, and values. For example, HS often works directly with subsistence harvesters to collect fish during on-the-land camps with Indigenous co-investigators. After discussions with Elders and harvesters on fish handling, fish are collected by subsistence fishers and jointly prepared by harvesters and scientists as both a community food source and source of samples for study. All handling is done in accordance with local customs and values. When applying for an animal use permit, HS was informed that all Indigenous harvesters would have to take an online animal care training course administered by the institution, and that the methods for euthanasia would have to be altered. The profoundly disrespectful and colonialist nature of directives and guidance like this—which occur in

all institutions—reflect ignorance of Indigenous ways of being. These situations also put researchers in a very difficult position, as they must choose to obey the rules set out by their institution and appear offensive and arrogant toward their Indigenous partners (thus losing social license), or pay heed to the guidance given them by Elders and Indigenous Knowledge Keepers and break the rules set out by the institution. Animal Ethics Committees need to consider the cultural context in which animal research is occurring and involve Indigenous advisors, especially when that research is occurring on the land and not in a laboratory (Sylvestre et al. 2018).

Call 5: We call upon natural scientists to provide meaningful opportunities for Indigenous community members, particularly youth, to experience and participate in science.

Fostering future generations of Indigenous researchers is a commonly stated objective of Indigenous communities (e.g., Inuit Tapiriit Kanatami 2018). The Indigenous population in Canada has grown by almost 43% since 2006. Thus, a good portion of the population is younger than 14 years old: ~30% of First Nations and Inuit and 22% of Métis (Statistics Canada 2017). Attainment of basic literacy in mathematics and science is low among Indigenous students in elementary and secondary schools as outlined in our introduction. We call on researchers to advance the TRC Call 10.ii to improve education attainment levels. We believe that natural scientists can provide very unique opportunities to engage youth by bringing them out on their traditional territory while exposing them to technology and science. Skills, understanding, and capacity can be built from these field experiences, particularly if Indigenous youth are hired as field technicians.

Kluane First Nation has had success with researchers who have established relationships with Kluane First Nation youth and provided them meaningful educational and work opportunities, while linking research with cultural revitalization. Ron Chambers, a Champagne and Aishihik Elder, described how his summer job as a student with an archaeologist changed how he looked at the landscape and he went on as an adult to discover multiple significant cultural sites in the region. Another showcase example is the fish contaminant study of *Lhù'ààn Mân'* (Kluane Lake), Yukon, conducted as a partnership among Arctic Institute of Community Based Research (AICBR; NK), HS, and Kluane First Nation. As AICBR had established relationships in the community both personally and professionally, AICBR and HS were able to create opportunities for students to engage in activities using both Indigenous Knowledge and scientific methods. Students took part in fish netting and sampling at sites identified through Indigenous Knowledge interviews conducted by the students. Students were also able to travel to University of Waterloo to work in the lab and analyze their samples. Not only did this provide important technical experience not available in Yukon, it allowed them to experience life on campus. Results were communicated to the community by the students and were better received because the students had been a part of the entire process. From interviews given by the students, it was obvious that the opportunity engaged them on a deep level and gave them confidence to consider work in STEM fields.

Call 6: To decolonize the landscape, we call on natural scientists to incorporate Indigenous place names as permitted.

Using Indigenous place names recognizes the long history of Indigenous peoples' relationship with the land—"the names are so old that we don't know how old they are" (MJJ, Kluane First Nation Elder). Unlike places named by non-Indigenous peoples that tend to immortalize individuals, Indigenous place names mark locations of significant happenings that could include celebrations, geologic features, or catastrophic events. The examples below are as told by MJJ, Kluane First Nation Elder. A river in Yukon is named *A'ǵy Chù* (By Itself Water) that flows from *A'ǵy* (By Itself), which references Observation Mountain, a mountain with a viewpoint surrounded by a glacier.

The river's English name, Slim's River, has much less meaning as it is named after a horse that died crossing the river during the Kluge Goldrush in the early 1900s. Indigenous place names can also advise on how to behave on the land or warn you of potential danger. For example, in Yukon, Congdon Creek was named after Frederick Congdon, a lawyer who served as Yukon's fourth Commissioner, but only lived about 10 years in the territory. However, its original name of *Khàr Shan Nji* (Place of Broken Roots) carries a much larger meaning—one warning about trees being carried down the river canyon during times of high water.

A map using Indigenous place names tells a story of the land—where gophers are when they are fat, where moose might be plentiful, and where volcanic eruptions happened—which is a stark contrast to a map using Western names that mostly marks one-time visits by early surveyors, mining recorders, or other non-local white men. By placing the Indigenous name first followed by the English name in maps and text associated with scientific research, users are recognizing the stories and the Indigenous Knowledge behind the names. As with all Indigenous Knowledge, these place names can only be used in the correct context and with permission. Using Indigenous place names also recognizes that the Indigenous name was there first in addition to helping efforts to reaffirm Indigenous languages and to keep the cultural landscape alive. This call echoes the TRC Call 13 to Acknowledge Aboriginal languages as well as one of the intents of [Association of Canadian Deans of Education's \(2010\)](#) Accord on Indigenous Education to promote the use of Indigenous languages in research and scholarly writing.

Call 7: We call upon natural scientists and their students to take a course on Indigenous history and rights.

The TRC calls for the need for education on the history of Indigenous peoples including the history and legacy of residential schools, the United Nations Declaration on the Rights of Indigenous Peoples, and Treaties and Aboriginal rights. While their calls were directed toward public servants of all levels of government (Call 57) and on elementary classrooms (Call 62.ii), we specifically identify a need for this education early in the university education of young natural scientists. Three of the authors review and issue research permits in Yukon. The majority of these research applications demonstrate ignorance of the social-political landscape in Yukon and the powers of Yukon Self-Governing First Nations and why things in northern Canada might work differently than in the south. This ignorance applies to both applications from scientists early in their careers as well as from well-established scientists. Requiring a mandatory course on Indigenous history and rights taught by Indigenous instructors for all undergraduate students would follow the lead of University of Winnipeg (Winnipeg, Manitoba), Trent University (Peterborough, Ontario), and Lakehead University (Thunder Bay, Ontario). We also encourage natural scientists that teach to develop a deeper commitment to exposing students to Indigenous Knowledge and approaches to the land. For example, for a course on forest ecology such exposure could come from visiting Indigenous Elders to talk about Indigenous fire management or the importance of medicinal plants.

Call 8: We call on funding bodies to change approaches to funding.

Considerable progress has been made in the past three years with respect to funding research that is led by or involves Indigenous peoples, but more action is required. We encourage funding bodies to prioritize research that directly responds to and involves Indigenous communities and to involve Indigenous reviewers in funding decisions. Specifically we recommend that funding bodies: (i) develop funding envelopes that are dedicated to Indigenous applicants undertaking natural science research (including Indigenous organizations and governments) and support these envelopes with dedicated and culturally aware program officers; (ii) simplify and streamline proposal templates and review criteria so that it is feasible for Indigenous organizations and communities to complete

applications; *(iii)* recognize that Indigenous organizations often do not have the same administrative capacity as a large academic institution, and revise reporting requirements to focus on broad outcomes rather than process; *(iv)* develop areas of strategic focus for natural science research based on consultations with Indigenous communities and organizations; *(v)* revise rules for eligible expenses and accounting requirements to reflect realities in Indigenous communities (e.g., there is a need for daily, immediate cash payments and honoraria for workers and Elders (Sylvestre et al. 2018)); *(vi)* allow carry-forward in multi-year funding agreements so that Indigenous recipients and their natural scientist collaborators have the ability to efficiently adapt to changing capacity and other challenges that are so often encountered in remote and underserved environments; and *(vii)* value Indigenous Knowledge in assessments of expertise of the applicants. Assessment of the merit of Indigenous applicants must, in many cases, be completely redeveloped. In a recent proposal submission co-applicants who were Indigenous Guardians from a northern community were asked to submit curriculum vitae to an online portal; this was egregiously inappropriate and disrespectful as well as being technologically impossible. We also encourage funding bodies to consider review of natural science research by a research ethics board that includes Indigenous advisors if the research occurs on Indigenous lands regardless if humans are involved in the research to ensure some degree of community engagement.

Call 9: We call on editors of all scientific journals to recognize that publication of research on Indigenous Knowledge and cultural resources require review and permission from the respective Indigenous communities.

We are not aware of any natural science journal with guidelines on how to appropriately publish Indigenous Knowledge or information on cultural resources. Guidelines should follow principles of OCAP® and those in the National Inuit Strategy on Research to recognize specific community ownership of Indigenous Knowledge and Indigenous rights to exert control of the review process. A review of research that is on cultural resources or uses Indigenous Knowledge, including Indigenous place names or words in Indigenous language, by the relevant Indigenous community is essential to correct any cultural inaccuracies, validate findings, and give respect to Indigenous Knowledge (Adams et al. 2014). The peer-review process for journals needs to be transformed to include a review from an Indigenous perspective when appropriate, i.e., place equal importance on this type of review as peer-review by technical experts.

Scientists may fear that their publication may get held up by disagreements on interpretations, but Article 9.17 of TCPS 2 offers guidance for this scenario. TCPS 2 suggests that if the disagreement cannot be resolved then researchers should either provide the community with an opportunity to make its views known, or report the disagreement in resulting publications. In our view disagreements are less likely to occur if meaningful relationships are in place, i.e., if you had the social license to conduct the research, and results were communicated regularly, disagreements are less likely.

Publication in a scientific journal is the grand finale of research. Unfortunately, Indigenous communities have no control on what ultimately gets published, regardless of conditions stipulated in research permits or data sharing agreements. The absence of a respectful review process on Indigenous Knowledge in journals was emphasized recently to three of the authors when they had to deal with the political aftermath of a published journal paper that used dendrochronology to date cultural resources. This paper published a map of sensitive locations and presented cultural interpretation without review by either of the First Nations that were closely involved with the original project. This incident damaged existing relationships, decreased the First Nations' trust with all researchers in their territories, and led to greater restrictions on research permits.

Call 10: Finally, we call on all natural scientists and postsecondary research institutions to develop a new vision for conducting natural science: fundamentally mainstreaming reconciliation in all aspects of the scientific endeavor, from formulation to completion.

Reconciliation requires a new vision for conducting natural science. Our on-the-ground experience with research permitting in a national park cooperatively managed with two First Nations where all governments must agree to approve the research, suggests a need for individual natural scientists to internalize this and find new ways for conducting science. A common question we receive about research permitting is whether consultation with Indigenous communities is required. True reconciliation requires going beyond what is required. Whether or not formal consultation is required, reconciliation means engaging with Indigenous communities well before the research permit application is written to ascertain interest in participation and to understand pressing questions that the communities have that the researcher may help to address. It does not necessarily mean developing full community-based participatory research nor loss of academic freedom (Alcantara et al. 2017), but it could mean finding opportunities for reciprocity such that both the community and the natural scientist benefit. Opportunities could range from hiring Indigenous peoples in field work, to donating some in-kind technical advice to a pressing community question, to sharing science in the classrooms. Demonstration of such early engagement with Indigenous communities is essential for obtaining a research permit in the Northwest Territories (Aurora Research Institute 2019).

There are many locations in Canada where Indigenous communities are not formally involved with research permitting, as various governments interpret obligations to consult with Indigenous communities differently. An additional challenge is that many Indigenous communities do not have the capacity to fully participate. In these situations, we argue that academia is not as bound to jurisdictional boundaries and have more flexibility and creativity to enable reconciliation.

Conclusion

“For far too long, researchers have enjoyed great privilege as they have passed through our communities and homeland, using public or academic funding to answer their own questions about our environment, wildlife, and people. Many of these same researchers then ignore Inuit in creating the outcomes of their work for the advancement of their careers, their research institutions, or their governments. This type of exploitative relationship must end.” (National Inuit Strategy on Research; Inuit Tapiriit Kanatami 2018).

Much of what is outlined in our paper suggests a new element to a social contract for natural scientists. In 1998, then-President Jane Lubchenco, in her Presidential Address to the American Association for the Advancement of Science, called for a new social contract between scientists and society to deal with the emerging global change (Lubchenco 1998). She presented the new social contract as a commitment on the part of all scientists to devote their energies to the most pressing problems of the day and to share knowledge widely in exchange for public funding. In 2017 Lubchenco reiterated her call for a new way of conducting science, calling for a “quantum leap into relevance” which was echoed by Keeler et al. (2017) in the need for institutions to reward societal impact as a core responsibility of academia, particularly in the face of climate change. In Canada we argue that another element is required in the new social contract to redress past exploitation of Indigenous peoples by scientific research: natural scientists must commit to reconciliation with Indigenous peoples and be recognized by academic institutions for their efforts.

The last few years have been positive for reconciliation and natural science research in Canada. The Tri-Council is due to release a strategy for new ways of research by and with Indigenous Communities (*The Strengthening Indigenous Research Capacity*). The Indigenous Research Capacity and Reconciliation—Connection Grants were offered in 2018 by SSHRC to enable knowledge mobilization within Indigenous communities and NSERC currently offers small awards for Indigenous Student Ambassadors. There was a session on engaging with Indigenous Communities on the 2019 agenda of the annual meeting of the Canadian Council of Deans of Science. More conferences (e.g., ArcticNet) and professional societies (e.g., Society for Environmental Toxicology and Chemistry) are actively working to support and promote reconciliation through cross-cultural exchanges, sessions, and workshops on Two Ways of Knowing and training of young researchers in community engagement. In the last two years there have been numerous new science camp initiatives offered by postsecondary institutions for Indigenous grade students. Furthermore, some academic institutions are also starting to value engagement with Indigenous peoples in assessments of merit and productivity of academic staff.

One of the current risks is the debasement of the spirit of reconciliation as institutions and individuals scramble to show they are making progress and resort to tokenism. We emphasize that to mitigate this risk, institutions, funding agencies, and individual scientists need to resist the urge to colonize the process of reconciliation itself (Kovach 2009). Reconciliation will necessarily be long and deep, and must not devolve into a shallow series of box-ticking exercises. We hope our Calls to Action empower individual scientists to work with Indigenous communities to develop and enact a new social contract that includes the building blocks of reconciliation into the research process.

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Author contributions

CW, KB, LI, MJ(G)J and HS conceived and designed the study. CW analyzed and interpreted the data. CW, KB, LI, MJ(G)J and HS drafted or revised the manuscript.

Competing interests

The authors have declared that no competing interests exist.

Data availability statement

All relevant data are within the paper.

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