Incorporate Indigenous perspectives for impactful research and effective management

Indigenous knowledge and ecological science have complementary differences that can be fruitfully combined to better understand the past and predict the future of social-ecological systems. Cooperation among scientific and Indigenous perspectives can improve conservation and resource management policies.

Natalie C. Ban, Alejandro Frid, Mike Reid, Barry Edgar, Danielle Shaw and Peter Siwallace

Many ecologists and environmental scientists wish to contribute solutions to pressing conservation problems, such as biodiversity loss or climate change, yet are unaware that their research might occur in places where Indigenous cultures have a long history of traditional proprietorship, place-based knowledge, governance and resource management. We argue that ecologists and conservation scientists should cooperate — work together towards mutual goals — with Indigenous knowledge-holders on whose territory they wish to do research. Such collaboration would be consistent with internationally recognized Indigenous rights[1], and generate more impactful research outcomes[2–4]. We illustrate these points by sharing our collective experience from three perspectives (see Author contributions).

Indigenous peoples have long histories of place-based living and oral traditions that have generated intricate knowledge about their lands and waters. Such knowledge is embedded in their worldviews and lifeways[5–7]. Indigenous cultures, however, have been undermined and repressed by colonial histories in many countries (for example, residential schools in Canada[8]; the 'Stolen Generations' in Australia[9]). As a step towards repairing past wrongs, 145 countries adopted the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP). This declaration specifies, among others, the right to "free and informed consent prior to the approval of any project affecting their lands or territories and other resources"[1]. Although originally targeted at states, that right also applies to field research. Research conducted without consent and outside a collaborative framework, no matter how well intended, can be a form of colonialism that disregards pre-existing knowledge, potentially harming Indigenous peoples[10,11]. In contrast, collaborative research engages Indigenous perspectives and pre-existing knowledge, and can therefore generate and test hypotheses with stronger implications for broad ecological understanding, social justice and Indigenous governance[3,12,13].

Indigenous knowledge and ecological science

In the context of this Comment, 'Indigenous knowledge' refers to ecological knowledge held by place-based Indigenous peoples, accumulated intergenerationally within their specific cultural context and belief system (traditional ecological knowledge), and often supplemented by contemporary observations on local-to-regional scales (local knowledge). Indigenous individuals can be holders and practitioners of Indigenous knowledge while also being ecologists or resource managers who apply the tenets and tools of Western science[7,14].

Indigenous knowledge and ecological science are complementary — potentially informing each other to enhance research and management outcomes — yet also have important differences (Fig. 1). A salient commonality is that Indigenous knowledge-holders and ecologists seek to understand environmental and ecological forces that affect the abundance and distribution of plants, animals and other organisms — for example, the effects of predation, exploitation by humans and nutrient flows. Both also strive to predict changes in biological communities in response to perturbations caused by human activities (for example, fisheries) or other factors (for example, natural disturbance). Importantly, Indigenous knowledge and ecological science recognize the interconnection of all living and physical entities, and that some species may have larger roles than others in maintaining the resilience of ecosystems[5,6,14,15].

Yet despite these commonalities, the two knowledge systems have complementary differences. Ecologists strive for local-to-global scope in their research objectives, which better prepares them to predict novel phenomena, such as the influx of new species induced by anthropogenic climate change or the impacts of ocean acidification. Meanwhile, Indigenous knowledge focuses on local-to-regional places and resources, which can yield longer historical baselines, superior natural history knowledge and understanding of variability on fine spatio-temporal scales[10,15,16].

Although both ways of knowing rely on observation and experimentation, ecologists focus on quantitative measures whereas Indigenous peoples generally focus on qualitative signals indicating directional or relative changes in the state of ecosystem components. The tradeoffs are that quantitative measures that are difficult or expensive for ecologists to obtain in the field often are fragmented in space and time, whereas qualitative observations made over widespread areas may be collected and integrated continuously by networks of socially connected fishers, hunters and plant gatherers[2,7].

Another difference is that ecologists capture their predictions in theory, often invoking mathematics, while Indigenous peoples capture theirs in traditional laws and stories that often merge long-term observations and oral histories with beliefs and spirituality[5–7,15]. Thus, super-natural aspects inherent to traditional laws and stories may encapsulate key interpretations of natural phenomena yet often are not falsifiable, highlighting the fact that science and Indigenous knowledge are complementary yet not equivalent[7] (Fig. 1).

Our view is that Indigenous peoples and scientists can, when appropriate and desired by Indigenous knowledge-holders, fruitfully combine their different ways of understanding the past and predicting the future, thereby improving conservation and resource management policies[4,7,17]. Collaborations that realize this potential are most likely to develop when individual scientists bring two qualities to their work. The first is openness to learn about Indigenous perspectives, knowledge and practices that may shape hypotheses or

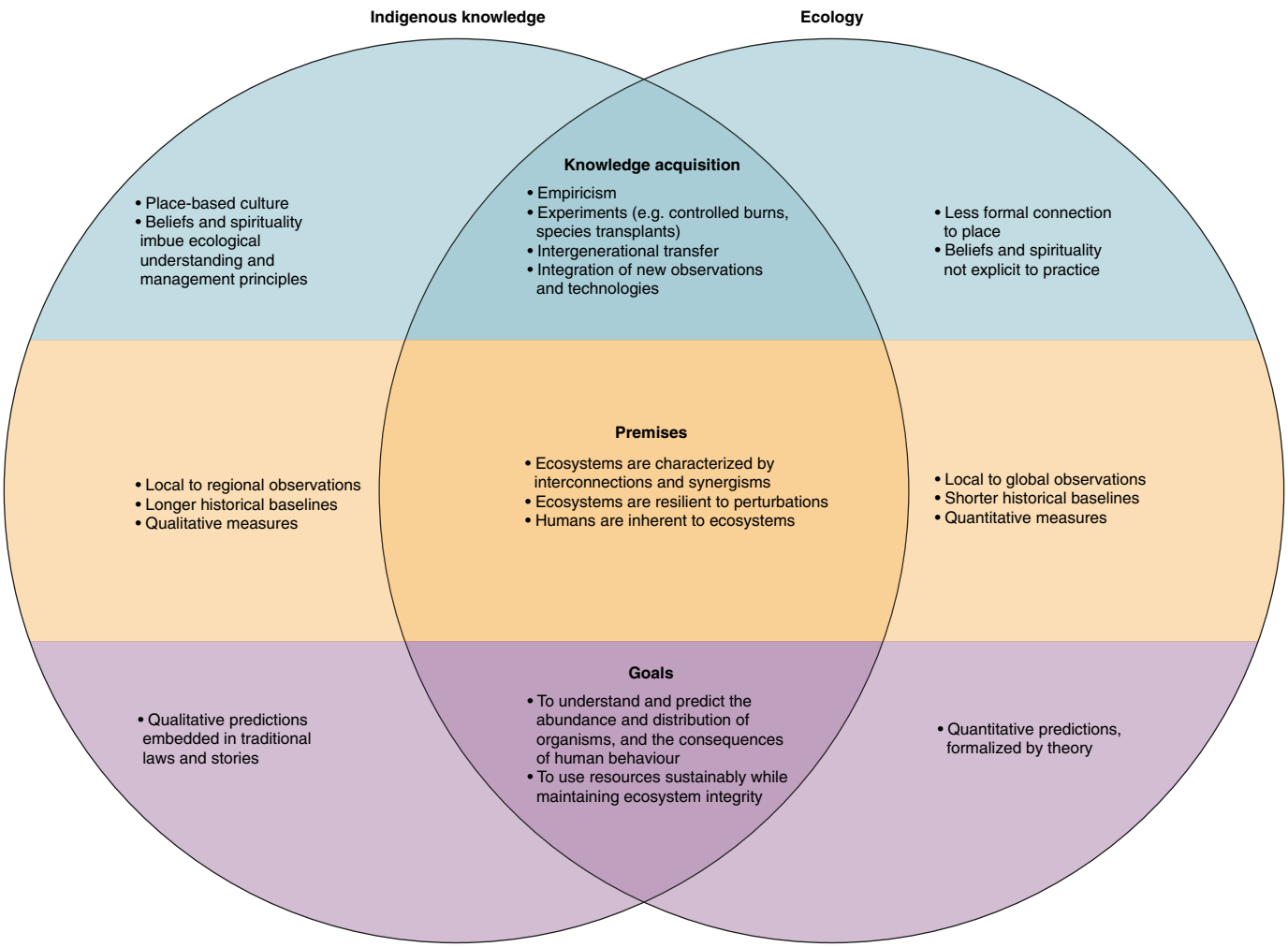

Fig. 1 | Salient commonalities and complementarities between Indigenous knowledge and ecology.

research questions. The second is an ability to recognize Indigenous knowledge as its own source of insights that can, synergistically with science or on its own, enhance our understanding of the natural world[2,7].

Much of our experience linking Indigenous knowledge and ecological science to advance marine conservation can be distilled into three broad stages (Box 1). A research need is often identified when long-term observations by Indigenous peoples recognize a change in species or ecosystems. Indigenous knowledge and scientific tools may then coalesce to generate and test hypotheses, before dialogue and negotiation is started with the agency responsible for management. In the case of our work, this has led to actual policy changes that honoured First Nation requests for spatial fishery closures.

Challenges

Despite being dominated by positive outcomes, our experiences also include challenges in linking Indigenous knowledge and scientific approaches. Foremost, it takes time to build relationships. A fast pace of research expected by many in academia may be unrealistic, at least initially while those relationships are being built. Also, Indigenous resource management offices are generally understaffed, and personnel are often busy with urgent priorities, such as responding to proposals for resource extraction, or addressing imminent environmental damage such as oil spills. These limitations further affect the pace at which research might occur.

Critically, while scientists are expected to publicly disseminate their findings, not all Indigenous knowledge is appropriate to share. For instance, the locations of ecologically and culturally important areas are particularly sensitive, for example where traditional foods are harvested, as they may reveal 'hotspots' for potential exploitation by others. This challenge can be partly overcome by using the highest spatial resolution of data for analyses that do not disclose sampling locations (for example, generalized linear models), while omitting or decreasing spatial resolution in maps displaying those locations[18]. Indeed, the World Intellectual Property Organization has developed a policy for no disclosure of Indigenous knowledge[19].

Another challenge is that Indigenous knowledge and science sometimes result in incongruent findings. For example, in the 1970s scientists estimated that bowhead whales in Arctic Alaska had a small population that could no longer withstand the traditional Iñupiat hunt. Iñupiat hunters disagreed, asserting that whales were abundant and their whale hunt sustainable. Over time, the disagreement lead to collaborative research and the revised population estimates — which were greatly improved by integrating Iñupiat traditional knowledge with scientific tools — supported the hunters' assertions[10]. Although disagreements between scientists

Box 1 | Three stages of knowledge linkage

The Dungeness crab case study. **Problem identification.** Since the late 1990s, Indigenous fishers have identified declines in catches and abundance of Dungeness crab (*Cancer magister*) on the central coast of British Columbia, Canada, and inferred that these declines were due to an increase in commercial and recreational fisheries. Reduced access to Dungeness crab, which are an important traditional food, has impacted the food security and cultural practice of these First Nations (as some Indigenous peoples are known in Canada). Between 2007 and 2014, First Nations of British Columbia's central coast continually engaged Fisheries and Oceans Canada (DFO), the federal agency responsible for fishery management, requesting the closure of commercial and recreational fisheries in areas important to Indigenous fisheries for food, social and ceremonial (FSC) purposes. Despite FSC fisheries being constitutionally protected, DFO initially denied these requests, arguing that there was no evidence for a conservation problem or need for management intervention.

Knowledge integration. Given DFO's initial lack of response, in 2014 First Nations closed ten bays to commercial and recreational fishing. These spatial fishery closures were not federally legislated; rather, they were implemented under Indigenous laws that require hereditary chiefs — who are the proprietors of marine tenures — to protect resources within their tenure areas[6,25]. They then directed their scientific staff to use these closures as a large-scale ecological experiment testing for fishery effects on crab populations. The experiment included ten control sites where commercial and recreational fisheries were allowed, and all 20 sites were monitored for up to ten months. The body size and relative abundance of adult male crabs increased over time at closed sites but declined at open sites, suggesting that non-Indigenous fisheries had contributed to the declining catch rates experienced by First Nations[26]. This work was followed by a partnership between First Nations and university researchers that integrated Indigenous knowledge (obtained through semi-structured interviews) with ecological modelling, thereby solidifying evidence for long-term declines of Dungeness crab and the inability of Indigenous fishers to sustain their traditional diets[24].

Dialogue and negotiation. Starting in 2017, evidence produced by the above studies became the focus of constructive discussions and negotiations between central coast First Nations and DFO. To date, the outcomes include four spatial closures for commercial fisheries (federally legislated in 2017–2018), and a joint technical working group (involving First Nations, their scientific staff and DFO) dedicated to the recovery and management of Dungeness crab in the central coast of British Columbia.

Credit: Tristan Blaine

and Indigenous knowledge-holders may not always be resolved (for example, thick-billed murres in Greenland[20]), ecologists can gain a lot by viewing contradictory findings as opportunities to revise and test hypotheses[2].

Recommendations for ecologists

Based on our personal experience and that of others[21], we make several recommendations to foster collaboration between scientists and Indigenous peoples[17,22]. First, researchers should find out on whose territory or territories their research takes place and reach out to local Indigenous resource management organizations. Some of these organizations may already have publicly available guidelines for researchers[22]. It is imperative to study these guidelines prior to initiating communications, and to understand that relationship-building will take time. Second, abide by the principle of "free and prior informed consent" stated in the UNDRIP[2], and other ethical guidelines such as those developed by the International Society of Ethnobiolgy[23], before implementing projects in Indigenous territories, especially if these involve invasive field techniques such as manipulative experiments, tranquilizing and radio-collaring animals or specimen collections. Follow Indigenous protocols for developing research partnerships. For example, in the case of the Dungeness crab research (Box 1), the university-based researchers developed research protocol agreements with each of the four First Nations. Research protocol agreements should specify, among other items[22], data ownership (for example, joint ownership versus exclusive proprietorship by individual knowledge-holders), constraints

to public dissemination of sensitive data, and guidelines for including Indigenous knowledge-holders as co-authors of research reports.

Ultimately, to co-create relevant research priorities in collaboration with Indigenous peoples, scientists must foster a deeper sense of connection with the places, cultures and individuals inherent to the work. Some may criticize this view as leading to loss of scientific objectivity, yet it is important to recognize that while hypothesis testing must be objective, hypothesis generation involves subjectivity. All scientific questions and hypotheses reflect the interest, and therefore biases and worldviews, of the individual scientist who generates them. If a scientist works in isolation from Indigenous peoples, chances are that the hypotheses he or she generates and tests will not be relevant to that group. The implication is that, in these cases, policymakers may lack the data to manage resources in a socially just way. Further, given the superior natural history understanding and often longer historical baselines inherent to Indigenous knowledge, scientists choosing to collaborate with Indigenous peoples may find themselves generating better hypotheses and producing more impactful research that advances management and conservation[2,3,10,15,24]. ❐

Natalie C. Ban[1,7*], Alejandro Frid[1,2,7], Mike Reid[3], Barry Edgar[4], Danielle Shaw[5] and Peter Siwallace[6]

[1]*School of Environmental Studies, University of Victoria, Victoria, British Columbia, Canada.* [2]*Central Coast Indigenous Resource Alliance, Campbell River, British Columbia, Canada.* [3]*Heiltsuk Integrated Resource Management Department, Heiltsuk First Nation, Bella Bella, British Columbia, Canada.* [4]*Kitasoo/Xai'xais Integrated Resource Authority, Kitasoo/Xai'xais First Nation, Klemtu, British Columbia, Canada.* [5]*Wuikinuxv Resource Stewardship, Wuikinuxv Nation, Wuikinuxv, British Columbia, Canada.* [6]*Nuxalk Stewardship Office, Nuxalk Nation, Bella Coola, British Columbia, Canada.* [7]*These authors contributed equally: Natalie C. Ban, Alejandro Frid.*

**e-mail: nban@uvic.ca*

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Author contributions

Our contributions to this piece come from three perspectives: an academic who partners with Indigenous peoples in her research (N.C.B.), an ecologist who conducts and facilitates research collaboratively with an organization of four Indigenous peoples (A.F.), and resource managers and Indigenous knowledge-holders from the Heiltsuk, Kitasoo/Xai'xais, Wuikinuxv and Nuxalk First Nations of British Columbia, Canada (M.R., B.E., D.S. and P.S., respectively). N.C.B. and A.F. drafted the paper (equal contribution). M.R., B.E., D.S. and P.S. guided the appropriate representation of Indigenous perspectives and edited the paper.

Competing interests

The authors declare no competing interests.