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Understanding Indigenous knowledge of conservation and stewardship before implementing co-production with Western methodologies in resource management: A focus on fisheries and aquatic ecosystems

Tribal Food Systems Research Fellowship

FIRST NATIONS DEVELOPMENT INSTITUTE

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Abstract

In the face of an increasing global human population and multiple anthropogenic environmental stressors including climate change, the limitations of relying solely on Western science and approaches to mitigating impacts, conserving biodiversity, and managing resources sustainably is

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apparent. Many Indigenous Peoples have lived sustainably as part of their respective environments for millennia, passing conservation and management practices down generations despite colonization and genocide. Long-standing Indigenous knowledge and philosophies offer alternate worldviews that can complement Western conservation and resource management and may strengthen efforts to restore environmental integrity and conserve species and ecosystems. Researchers often tout the co-production of knowledge with Indigenous collaborators using frameworks like the Kaswentha (Two Row Wampum—Haudenosaunee) and the Etuaptmumk (Two Eyed Seeing—Mi'kmaw) without first seeking to understand the foundations of Indigenous knowledge itself, and its deep roots in environmental sustainability. We develop a thesis of the embedded relational nature of Indigenous knowledges and the unique strengths and perspectives that must be understood before effective and ethical co-production can be possible. We contend that Indigenous knowledge must be treated as a distinct framework to inform conservation and stewardship of biodiversity and nature, rather than selectively integrating it into Western science. Building relationships with local Indigenous nations will help actualize sustainable practices that are rooted in millennia of empirical data. This will help to promote a shift toward a holistic and relational worldview for more impactful conservation action.

Keywords
Indigenous knowledge, resource management, fisheries, knowledge co-production, conservation, sustainability, worldview

Introduction

We are experiencing the widespread, rapid, and unprecedented degradation of ecosystems worldwide, with loss of species, compromised ecosystem functions, and diminished 'ecosystem services' to human communities. Essentially, within a single generation, the integrity and functioning of many ecosystems have collapsed, caused by myriad interacting anthropogenic stressors that include invasive species; pathogens that cause both wildlife and human disease; habitat loss, fragmentation, and degradation; increasing rates of resource extraction (mining, forestry); and rampant pollution (Dudgeon et al., 2006; Reid et al., 2019). The impacts on biodiversity are staggering. The United Nations Intergovernmental Science–Policy Platform on Biodiversity and Ecosystem Services (IPBES, 2019) estimates that 1 million terrestrial, freshwater, and marine species are at risk of extinction globally, a rate of loss that is unprecedented in human history. The World Wildlife Fund's 2024 Living Planet Index (WWF, 2024) integrating temporal data for approximately 35,000 populations of 5,495 vertebrate species worldwide shows an overall decrease in biodiversity greater than 73% between 1970 and 2020. Freshwater species are disproportionately impacted by these human stressors, with declines exceeding 80% and the rate of loss expected to increase over the next few decades (WWF, 2024). While Western science often effectively diagnoses the proximate causes of biodiversity loss, conservation practitioners and policymakers struggle to "translate information into action" and thus to develop effective conservation and stewardship approaches that will slow or mitigate the human impacts (Buxton et al., 2021). Western scientific approaches alone are likely insufficient to monitor, mitigate, or reverse ecosystem declines, and some recommend embracing Indigenous insights and practices (e.g., Jardine, 2019; Jessen et al., 2022; Mervis, 2023).

Many Western science–based conservation initiatives suffer from changing notions of reference ecological conditions (that is, shifting baselines; see Soga & Gaston, 2018)—the ecological state(s) to which we may wish to return a particular region (Jardine, 2019). This means that the ultimate goals of many conservation actions for mitigating or reversing impacts on ecosystems are often ill-defined, and that the most effective practices to achieve enduring conservation are seldom implemented (Pauly, 1995). Modern Western conservation movements arguably started only in the 19th and early 20th centuries (Sodhi & Erlich, 2010); thus, formal documentation of human environmental impacts associated with preceding centuries is often sparse and inconsistent, and many stewardship regimes are focused on shorter-term actions (Barton, 2002; Morrison, 2019). Despite rapid and

profound technological advances and the obvious, continued negative effects of industrialization, global trade, and human population growth, environmental impacts and conservation challenges remain largely unaddressed—with significant political and socioeconomic impediments precluding the adoption of effective strategies in many jurisdictions (WWF, 2024). The insights available from Indigenous cultures, knowledges, and philosophies can complement Western scientific efforts and may provide effective means to achieve conservation and undertake meaningful, impactful stewardship (Heller et al., 2023; Ransom & Ettenger, 2001).

In contrast to Western ecological science and conservation biology, which mostly arose in the 20th century, Indigenous knowledge is the place-based accumulation of ways of knowing, being, and doing across multiple generations (Jessen et al., 2022). Indigenous knowledge then is comparable in important ways to the accretion of scientific data, but is embedded within and reflects the worldview of each Indigenous nation. Although each nation is unique and we should eschew pan-Indigeneity,[1] comparisons of cultures do reveal important common themes in terms of respect, relationality, and reciprocity with the natural world. For example, Indigenous holistic and relational approaches to addressing environmental issues bring perspectives and practices that have proven historically effective for sustainable management and co-existence with all relations (Campbell & Butler, 2010; Groesbeck et al., 2014; N. J. Wilson & Inkster, 2018). Reflecting this, our goal in this paper is to illustrate how Western scientific approaches to conservation (with a focus on freshwater ecosystems) would benefit from understanding how the worldviews and practices of many Indigenous Peoples can move us closer to long-term sustainable practices rooted in a collective understanding and relationality (S. Wilson, 2008). We highlight current and historical frameworks for co-producing knowledge but emphasize that we must first seek to understand the underlying principles and philosophies of knowledge systems prior to braiding them. Our focus here will be fisheries and the conservation of aquatic ecosystems and species, both because this is something we have studied using environmental DNA (Maracle et al., 2024) and because there are compelling case studies of sustainable Indigenous practices. We start with a general discussion of frameworks for co-producing knowledge, the importance of respect and reciprocity, and the centrality of place and relationality in Indigenous conservation and food security. We then delve more deeply into how knowledge is generated and shared through culture. Finally, we explore how culture is maintained across generations through practice, or in other words, "ceremony" (S. Wilson, 2008).

Etuaptmumk and Kaswentha

The Etuaptmumk[2] (Two-Eyed Seeing) framework developed by Mi'kmaw[3] elders Albert and Murdena Marshall is a model for co-production of knowledge and has become a center point for developing and informing many research, conservation, and management projects (henceforth simply 'research') with Indigenous Peoples in Canada (Bartlett et al., 2012; Wright et al., 2019). Albert Marshall describes Etuaptmumk as seeing "… from one eye with the strengths of Indigenous ways of knowing, and to see from the other eye with the strengths of Western ways of knowing, and to use both of these eyes together" (Peltier, 2018, p. 2). Implicit in Etuaptmumk is the assertion that each knowledge system is distinct and whole, and that by "weaving them together" research will unfold in a collaborative and equitable manner (Bartlett et al., 2012; Wright et al., 2019). Albert Marshall further asserts that Etuaptmumk creates an opportunity for a researcher to understand different perspectives and therefore offers a more thoughtful and inclusive way of doing things (Bartlett et al., 2012).

Etuaptmumk allows different nations to use

[1] Pan-Indigenous refers to an approach to viewing and grouping Indigenous peoples that homogenizes groups of people who have distinct cultural, linguistic, geographical, and historical differences.
[2] Etuaptmumk - Mi'kmaw term for Two-Eyed Seeing. One eye views the world through Indigenous ways of knowing and the other eye through Western, or Eurocentric, ways of knowing. (Phonetic notation: Ed-do-up-dim-moomk).
[3] Mi'kmaw - First Nations people of the Northeastern Woodlands of Atlantic Canada. (Phonetic notation: MIG-mah).

their own teachings, thus making co-production of knowledge and solutions to environmental challenges meaningful and relevant to each nation. As another illustration, the Kenyen'kehà:ka[4] nation of the Haudenosaunee Confederacy[5] (to which two of the three co-authors belong), directs collaborators toward two pivotal wampum agreements: the Kaswentha[6] (Two Row Wampum) and Sewatokwà:tshera'[7] (Dish with One Spoon Wampum). Both agreements emphasize the collective responsibility of caring for the earth and sharing resources with other nations, both Indigenous and non-Indigenous (Jacobs & Lytwyn, 2020; Ransom & Ettenger, 2001). For Haudenosaunee scientists, upholding these wampums is integral to research, with the expectation of reciprocity. Collaboration with Indigenous Peoples is foundational to fostering inclusivity and appropriate representation for any conservation effort focused on a particular region, ecosystem, or species (Kusabs & Quinn, 2009; McCartney et al., 2023).

Attempts to adopt the Etuaptmumk framework that neglect Indigenous researchers has historically led to extractive and tokenizing outcomes that do not adequately acknowledge and build relationships nor value Indigenous practices and philosophies required to sustain the knowledge source itself and the people (Ludwig & El-Hani, 2020; S. Wilson, 2008). At the very least, this risks cultural appropriation, but it also can lead to racial biases that ultimately negatively affect research, its outcomes, and meaningful collaborative conservation. If Western scientists are settlers who lack a deep-rooted sense of place for the region being studied (e.g., a lake or river or watershed) and hold biased views of Indigenous Peoples and their knowledge systems, research may collapse into the historical, colonial relationships. Such biases, rooted in generations of hegemonic Western attitudes, can be ingrained and implicit. The consequence of this can be that proposed solutions to conservation challenges fail to address the role of Indigenous knowledge and cultural sensitivities, and the ethical responsibilities of working with communities and their sacred knowledge (Smith, 2021). In sum, using the Etuaptmumk approach means that Indigenous researchers and knowledge-keepers, with lived experience, must be involved from project conception, through information collection and interpretation, to design, deployment, and evaluation of conservation strategies.

Indigenous knowledge systems have existed since time immemorial and reflect generations of iterative experimentation and observation of human interaction with the local environment, passed down through successive generations so that each may be sustained and thrive (Stoffle et al., 2003). For example, Mohawk knowledge keeper Kanahkwahawi, in reference to relationship among plants, explained that western "science has proven … what we've already known" with respect to symbiotic relationships (Kanahkwahawi, Kenyen'kehà, Tyendinaga Mohawk Territory, interview with JM, July 14, 2024). Many Indigenous people see themselves as the original empirical scientists, whose experiences and practices reflect generations of "experimentation," a concept that merits attention. Indigenous knowledge firmly places humanity within the natural world, whereas Western science is typically based on a hierarchy where humans are not only apart from the natural world, but above it (Hendry, 2014). This notion is even embedded in some fields in ecology, whereas humans really must be viewed as one species among many (Dalrymple, 2022; but see European Environment Agency et al., 2023). Scholar Michael

[4] Kenyen'kehà:ka or Kenien'kehà:ka: Mohawk word for the Mohawk nation of Atlantic North America, meaning "people of the chert." (Phonetic notation: gah-NYEN-geh-hah-gah.)
[5] Haudenosaunee: Mohawk word for the Six Nations or Iroquois Confederacy in Atlantic North America consisting of First Nations peoples of the Mohawk, Oneida, Onondaga, Cayuga, Seneca, and Tuscarora nations. (Phonetic notation: How-den-o-show-nee.)
[6] Kaswentha: Mohawk word for the Two Row Wampum treaty, an agreement that arose from the initial meeting of Haudenosaunee and Dutch colonialists with three foundational principles: friendship and mutual respect; peace; and that the agreement would be forever. (Phonetic notation: Gus-wen-ta.)
[7] Sewatokwà:tshera': Mohawk word for the Dish with One Spoon Wampum treaty, an agreement between the Haudenosaunee and Anishinaanbeg that occupied shared territory in the Great Lakes Region and subsequently shared resources. Symbolizing using a shared resource "dish" with mutual co-operation and consideration "one spoon." (Phonetic notation: say-wah-doh-GWAH-say-rah.)

Christie advocates for the inclusion of Indigenous science to gain insight into how humans "fit into, rather that outside of the ecology" (Hendry, 2014, p. 44). Indigenous knowledge systems are built on a deeply felt and culturally embedded understanding of the inherent responsibility each person has to sustain the environment as its caretaker, emphasizing relationship and stewardship over any notion of rights to resources (Smith, 2021). While a pan-Indigenous lens can diminish cultural and historical distinctions among Peoples, including the foundational and pervasive concept of relationality with the living world should, as we argue below, underpin the conservation of water, aquatic species, and ecosystems, and indeed all of nature (N. J. Wilson & Inkster, 2018). Ultimately, then, Western scientists and the accompanying Western scientific approach must shift to allow space for the embedded relational nature of Indigenous knowledge to be woven into current conservation efforts (Tynan, 2021).

Etuaptmumk and the Kaswentha are examples of frameworks that underpin co-produced holistic and sustainable conservation efforts through implementation with local Indigenous Peoples and communities. For such efforts to be successful, a first step is to seek to understand, to value, and then to embrace (on some level at least) Indigenous knowledge and philosophies before addressing pressing environmental issues using both Indigenous and Western knowledge. In the following sections, we discuss some central aspects of Indigenous knowledge and the systematic and epistemological changes that need to be implemented before equitable co-produced management can arise. We illustrate this with some teachings from specific nations but emphasize the importance of understanding the values and practices of each nation.

Place and Relationality

Indigenous Peoples in North America have rich and diverse histories of coexistence with their respective ecosystems that extend back millennia, as do many Indigenous peoples worldwide (Breidlid, 2008; Kimmerer, 2015). The cultures of each region developed different and unique place-based practices that are vital to the survival of the people and persistence of local ecosystems; these are based on iterative observations of nature across generations. The culture and knowledge development of an Indigenous nation in one region is obviously then specific to the ecosystems within which its Peoples have historically lived and currently inhabit and maintain. Place and the relationality therein is central to the development of any Indigenous knowledge system as people co-exist with their environment and its relations over long spans of time.

Place, in Indigenous philosophies, resonates in some ways with the discipline of human geography comprising three facets; physical, social, and emotional (Agnew, 1987, as cited in Creswell, 2014). The difference, however, lies in understanding that humans are intrinsically part of the place shared with all living beings (biological, physical, and chemical beings are all considered animate), each of whom works to fulfill their respective responsibilities of maintaining balance within their shared environment (Little Bear, 2000). Place and the relationality of people within it influence what facets of specific knowledge systems might be applied elsewhere and if they cannot.

Some beliefs and values of ecosystems are indeed shared across many Indigenous Peoples, leading to similar cultural practices and a shared historical ecological knowledge. For example, a value deeply embedded within many nations is the sacred nature of water and the notion of water as a life source (Latchmore et al., 2018; McMillan & Prosper, 2016). While there will always remain distinctions, such key common aspects of Indigenous knowledge of aquatic ecosystems and approaches to fisheries management can serve as foundations for co-producing conservation knowledge and undertaking stewardship that might be generalizable to other nations, other regions, and to Western practitioners.

Knowledge Transfer Through Culture

A common Western misperception of Indigenous Peoples is invariably that they lived on the land historically in primitive fashion without altering or affecting change in their local environment and that they lacked sophisticated environmental insights or technologies (Pierotti, 2010). This misunderstanding has been exacerbated by colonial

biases and the assertion that Indigenous Peoples were uneducated, incapable of complex social constructs, or had simple foundations of knowledge. However, modern paleo-research and recognition of the sophistication of contemporary Indigenous knowledge and voice has brought into focus the reality of long-standing Indigenous knowledge, and, most relevant here, knowledge of fisheries and sustainable management of aquatic resources in the Americas (Alexander et al., 2019; Kakoty, 2018; Lepofsky & Caldwell, 2013). For example, both the coastal and inland Salish existed in sufficient densities to have potentially significantly impacted their local ecosystems and resources around them, yet some harvested species (e.g., Chinook salmon, *Oncorhynchus tshawytscha*) that showed no marked decreases in stock size over thousands of years but that were negatively impacted after the arrival of Europeans (Campbell & Butler, 2010).

Campbell and Butler (2010) assert that two main factors contribute to such fisheries sustainability by Indigenous Peoples: (1) broad dietary flexibility shifting with season and availability, and (2) formalized social and cultural beliefs, with the former being significantly influenced by the latter. Indeed, Indigenous Peoples' interactions with any species were not considered in isolation (by them) but rather in relation to all beings within the environment, biological and otherwise, and in consideration of the vulnerability of any particular species to exploitation. These ideas were coupled with the general philosophy that one should switch species rather than "fish down the food web" (Campbell & Butler, 2010; Groesbeck et al., 2014; Pauly et al., 1998). The Māori people of Aotearoa (New Zealand) practiced a similar conservation approach referred to as kaitiakitanga, which translates to care and guardianship (McAllister et al., 2023). A self-imposed quota for any limited resource including fish, called the Rahui (Maxwell & Penetito, 2007), responded to the natural ebbs and flows of wild populations observed in Aotearoa, thus providing an opportunity for repopulation (see Hendry, 2014).

Such holistic and sustainable practices are deeply embedded and maintained within cultures, often reflected in stories of practices being passed down directly from the Creator or because nature itself is considered a living entity (McMillan & Prosper, 2016). These knowledge systems accrue learnings from earlier generations through interactions with other beings within the environment, iteratively "correcting mistakes," and sharing corrections for the betterment of their communities and future generations. Instead of assuming that Indigenous Peoples have always innately known how to sustainably live with the environment, this implies that mistakes were made, that previous generations learned from nature and learned of the consequences of exploitation—and that ultimately these teachings were passed down through generations to ensure that such actions were not repeated (FiveCrows et al., 2025; McMillan & Prosper, 2016; Pierotti, 2010). The development of cultural stories and practices are part of the evolution of generational knowledge transfer. Stoffle et al. (2003) articulate how Indigenous practices become embedded in culture over hundreds of generations through the transfer of practices and values under many Indigenous worldviews—explaining how the first generation of Indigenous people in a new environment learns from nature through actions and consequences, but that, after approximately 150 generations, nature is recognized as the teacher, with each being having specific rights and responsibilities given by the Creator to sustain the whole (Stoffle et al., 2003). For example, the Haudenosaunee Sewatokwà:tshera' agreement likely arose from observing the negligent use of resources that negatively affected people of that time. This general concept of rights and responsibility teaches respect for all beings within an ecosystem, just as one human should respect another. Under this worldview, the relationships with and among beings are recognized and accepted. This leads to understanding that one's interactions with other beings may influence their ability (in turn) to fulfill their duties as intended, including sustaining humans as a part of the environment (Kakoty, 2018; Sheridan & Longboat, 2006). Whether Indigenous philosophy and practice are passed down from the Creator or are accrued through iterative observation and experimentation is of no concern really (in terms of their impacts on management, not their importance to people); rather, the lesson is that ecosystem management must come from a

place of humility and consideration of the "resource" as both teacher and kin from whom people can learn and for whom each person has responsibility to conserve so that future generations too may learn from it.

The Importance of Ceremony

Many Indigenous communities worldwide maintained productive, intact ecosystems through the notion of responsibility rather than right. Responsibility for nature and resources is deeply embedded in most Indigenous cultures and often conveyed through ceremonies and formalized through relationships with the natural world (Tewateronhianriks, Kenyen'kehà, Tyendinaga Mohawk Territory, interview with JM, July 6, 2024). For example, when fish start to run in the spring, many First Nations (e.g., Salish in present day British Columbia, Canada, and Oregon and Washington, USA) hold ceremonies which span the first few days of a migration to give thanks for the return of the fish but allowing the first fish to pass so that they may reach their spawning grounds (First Fish ceremony; Amoss, 1987; Lepofsky & Caldwell, 2013). Once fishing commences, this responsibility is continued by upholding designated fishing areas, days of rest during the season, and using selective harvest, allowing large fecund fish and small juvenile fish to survive. These practices are underlain by the notion that fish are a shared resource that other people and non-human kin depend on, so collection is often limited to what is needed and not more than half of what is available (Campbell & Butler, 2010; Kimmerer, 2015). Early anthropologists theorized that Indigenous sustainability was due to relatively small population sizes and suppression of large competing predators like bears (Alexander et al., 2019; Butler & Campbell, 2004). However, more recent assessments of Indigenous oral traditions and new palaeoecological data indicate how dietary flexibility and cultural values and beliefs played significant roles in maintaining resources (Campbell & Butler, 2010). For example, Pierotti (2010) notes the emphasis on non-equilibrium in Indigenous stories and ceremonies as a reminder of past events and recognition that such things can happen again; thus, thanks should be given now but steps should be taken to minimize impacts for the future. First Fish ceremonies are important examples of this (Amoss, 1987; Pierotti, 2010).

In North America, many Indigenous cultural values and beliefs situate important aquatic taxa like salmon, lampreys, and mussels in the realm of the sacred, in some cultures referred to as "First Foods" (FiveCrows et al., 2025; McMillan & Prosper, 2016; Quaempts et al., 2018). These First Foods are species identified by the Creator as taking care of the people in traditional stories. This understanding is maintained through cultural practices such as being served first at ceremonies and gatherings and being served only after water, which sustains all life including the First Foods. These practices remind people of the sacrifice the species continue to make and the reciprocity of responsibility that should be accepted to ensure the persistence of these species as First Foods (Hendry, 2014; Quaempts et al., 2018). Such reciprocity for individual species collectively helps to ensure that healthy ecosystems are maintained. Switching from one local native species to another as abundances change or by modifying habitats to increase yield of more vulnerable species serve as tangible actions for conservation (Campbell & Butler, 2010; Groesbeck et al., 2014).

Whether they were once allies or adversaries, many nations have enshrined agreements to share aquatic resources (Jacobs & Lytwyn, 2020). Common core values of stewardship and respect superseded all else and in these situations led to sustainable harvest practices, ranging from large treaties with shared responsibility such as the Sewatokwà:tshera' (Dish with One Spoon) to smaller community and individual practices including selective harvest locations, days of rest, shared weirs, and weirs and nets designed to allow passage of some fish (Atlas et al., 2021; Campbell & Butler, 2010; Jacobs & Lytwyn, 2020). These practices stem from philosophical beliefs and worldviews often with the foundational understanding that these species volunteered during Creation for the task of giving their lives to care for *all* humans. Without such respect, these caretakers (i.e., plants and animals) can be taken away (Amoss, 1987; McMillan & Prosper, 2016; Sheridan & Longboat, 2006; Wilson & Inkster, 2018). Understanding the role of culture in Indigenous practices and manage-

ment decisions facilitates embedding Indigenous management approaches and philosophies within ecosystem management and sustainability efforts, while simultaneously supporting and contributing to revivifying Indigenous languages, philosophies, and knowledge for future generations.

Meaningful Collaboration for Enduring Solutions

Indigenous knowledge does not fit into the formalized mold of Western science, with its emphasis on objectivity and, often, reductionism (versus relationality and holism). Where Western science incorporates no notion of spirituality while perceiving the physical world, Indigenous knowledge is unable to and indeed cannot separate them. This means that Indigenous knowledge systems are frequently treated as unsophisticated and inferior in addressing issues on conservation and management despite Western science often proving what Indigenous People already knew (Kanahkwahawi, Kenyen'kehà, Tyendinaga Mohawk Territory, interview with JM, July 14, 2024; Latulippe & Klenk, 2020). Western science must acknowledge and "trust that Indigenous people have the experience within our environment as original caretakers of the land since time immemorial" (Hendry, 2014, p. 45). In general, Western science continues to work under an anthropocentric worldview, treating humans as separate from the environment and as consumers of it and monetizers of its benefits, while seeing the environment as comprising a collection of resources without complexity (Smith, 2021; Stoffle et al., 2003). We must continue to strive toward a general Indigenous worldview, seeing humans as part of nature and recognizing that entities within nature have rights and responsibilities. Indeed, some ecologists already hold a version of this view, but until this view is shared (e.g., by policymakers, conservation practitioners, governmental resource managers), Indigenous knowledge and ceremony will remain unrelatable to Western methodologies (Latchmore et al., 2018; Ransom & Ettenger, 2001; Smith, 2021).

Collaboration between any Western scientist and an Indigenous community must first involve scientists seeking to understand the Indigenous worldview but also involve providing communities with the tools to navigate the modern scientific world, particularly in the context of the language and complex jargon that often attends scientific disciplines. Importantly, we must encourage and educate Indigenous scientists—who have both lived experiences (Indigenous knowledge beyond birthright) and understanding of Western scientific disciplines and their terminologies, and who respect the value of both knowledge systems while maintaining clear boundaries. Otherwise, the unique vantages of each cannot be effectively transferred or related to conservation, as is the aim of Etuaptmumk. Importantly, different frameworks like the Kaswentha and Etuaptmumk vary in the teachings they offer, and all must be aware of and value these differences.

Fisheries management and conservation in general have not been as effective and enduring of environmental change as they could be. We contend that incorporating Indigenous approaches and practices can help to rectify this, but that a lack of consideration of Indigenous knowledge, complicated by the enduring impacts of colonization, has often impeded progress. Actively (e.g., residential schools in Canada) or even inadvertently (e.g., underfunding remote Indigenous communities standard education as well as Indigenous language fluency programs) preventing the transfer of knowledge across generations increases the risk that millennia old practices and ways of knowing are at risk of disappearing with the loss of Indigenous, languages, cultures, and people.

Building capacity in Indigenous communities, fostering resurgence of knowledge, and ensuring that stewardship practices are passed down to future generations will enable more compelling conservation research, and more sustainable and effective co-management approaches. This does not mean incorporating Indigenous knowledge into science; indeed, many Indigenous knowledge-holders and Western scientists alike would consider this inappropriate. Rather, space needs to be made in modern research for Indigenous science and cultural practices, in line with Etuaptmumk (Bartlett et al., 2012; Latulippe & Klenk, 2020).

Our review here emphasizes the importance of understanding how Indigenous Peoples' worldviews affect their concept of relationality with the

natural world. The foundation of many Indigenous knowledge systems stems from cosmological relationality and respect for nature as comprising living entities (e.g., the concept of First Food provided by the Creator; McMillan & Prosper, 2016). Many Indigenous philosophies highlight reciprocity and responses to environmental unpredictability that must be embraced so that future generations may benefit from and experience healthy ecosystems just as those alive now have benefitted from the actions of their ancestors (FiveCrows et al., 2025; Pierotti, 2010). In contrast to "manipulating" and "controlling" the environment solely to maximize human benefit, incorporating Indigenous knowledge into aquatic resource management and stewardship requires that we change perspectives—for example, exhibit openness to listening carefully to our environment, asking how our relationships with all beings within it must change to improve environmental health.

Embracing relational approaches and considering the spiritual and emotional ramifications of an environmental issue can be considered within scientific research, but potentially at the risk of diminishing both Western science and Indigenous knowledge. "Cherry-picking" portions of Indigenous knowledge that align with Western science or adding color to a Western paradigm reduces the integrity of both. Shifting the paradigm from incorporating Indigenous knowledge into conservation and management where convenient, to viewing Indigenous knowledge and practice as a framework for an alternate way of solving environmental challenges, we assert, will be more impactful. Only when we all learn to listen to nature and see humans as inherently part of ecosystems, as both the problem and potentially contributing to solutions, can co-produced knowledge be incorporated into effective and sustainable conservation and stewardship practices (Heller et al., 2023).

References

Alexander, S. M., Provencher, J. F,, Henri, D. A,, Taylor, J. J., Lloren, J. I., Nanayakkara, L., Johnson, J. T., & Cooke, S, J. (2019). Bridging Indigenous and science-based knowledge in coastal and marine research, monitoring, and management in Canada. *Environmental Evidence, 8*, Article 36. https://doi.org/10.1186/s13750-019-0181-3

Amoss, P. T. (1987). The fish God gave us: The First Salmon Ceremony revived. *Arctic Anthropology, 24*(1), 56–66. http://www.jstor.org/stable/40316132

Bartlett, C., Marshall, M., & 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*, 331–340. https://doi.org/10.1007/s13412-012-0086-8

Barton, G. A. (2002). *Empire forestry and the origins of environmentalism*. Cambridge University Press. https://doi.org/10.1017/CBO9780511493621

Breidlid, A. (2009). Culture, indigenous knowledge systems and sustainable development: A critical view of education in an African context. *International Journal of Educational Development*, *29*(2), 140–148. https://doi.org/10.1016/j.ijedudev.2008.09.009

Butler, V. L. & Campbell, S. K. (2004). Resource intensification and resource depression in the Pacific Northwest of North America: A zooarchaeological review. *Journal of World Prehistory*, *18*(4), 327–405. https://www.jstor.org/stable/25801226

Buxton, R. T., Bennett, J. R., Reid, A. J., Shulman, C., Cooke, S. J., Francis, C. M., Nyboer, E. A., Pritchard, G., Binley, A. D., Avery-Gomm, S., Ban, N. C., Beazley, K. F., Bennett, E., Blight, L. K., Bortolotti, L. E., Camfield, A. F., Gadallah, F., Jacob, A. L., Naujokaitis-Lewis, I., Raudsepp-Hearne, C., … Smith, P. A. (2021). Key information needs to move from knowledge to action for biodiversity conservation in Canada. *Biological Conservation*, *256*, Article 108983. https://doi.org/10.1016/j.biocon.2021.108983

Campbell, S. K., & Butler, V. L. (2010). Archaeological evidence for resilience of Pacific Northwest Salmon populations and the socioecological system over the last ~7,500 years. *Ecology & Society, 15*(1), Article 17. https://doi.org/10.5751/ES-03151-150117

Creswell, T. (2014). *Place: An introduction* (2nd edition). Wiley-Blackwell.

Dalrymple, S. (2022 June 1). *Are humans separate from nature?* British Ecological Society. https://www.britishecologicalsociety.org/are-humans-separate-from-nature/

Dudgeon, D., Arthington, A. H., Gessner, M. O., Kawabata, Z.-I., Knowler, D. J., Lévêque, C., Naiman, R. J., Prieur-Richard, A.-H., Soto, D., Stiassny, M. L. J., & Sullivan, C. A. (2006). Freshwater biodiversity: Importance, threats, status and conservation challenges. *Biological Reviews, 81*(2), 163–182. https://doi.org/10.1017/S1464793105006950

European Environment Agency, Strand, R., Kovacic, Z., Funtowicz, S., Benini, L., & Jesus, A. (2023). *Exiting the Anthropocene? Exploring fundamental change in our relationship with nature*. Publications Office of the European Union. https://data.europa.eu/doi/10.2800/37883

FiveCrows, J., DeCoteau, A., Hess, J., Hatch, D., & Narum, S. (2025). Sharing biological information across generations: Parallels between indigenous knowledge and genetics for fisheries recovery in the Columbia River Basin. *Molecular Ecology Resources*, *25*(2), Article e13815. https://doi.org/10.1111/1755-0998.13815

Groesbeck, A. S., Rowell, K., Lepofsky, D., & Salomon, A. K. (2014). Ancient clam gardens increased shellfish production: Adaptive strategies from the past can inform food security today. *PLoS ONE, 9*(3), Article e91235. https://doi.org/10.1371/journal.pone.0091235

Heller, N. E., McManus Chauvin, K., Skybrook, D., & Barnosky, A. D. (2023). Including stewardship in ecosystem health assessment. *Nature Sustainability, 6*, 731-741. https://doi.org/10.1038/s41893-023-01096-7

Hendry, J. (2014). *Science and Sustainability: Learning from Indigenous wisdom*. Palgrave Macmillan New York. https://doi.org/10.1057/9781137430069

Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services of the United Nations [IPBES]. (2019). *Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*. IPBES Secretariat. https://doi.org/10.5281/zenodo.3553579

Jacobs, D. M., & Lytwyn, V. P. (2020). Naagan ge bezhig emkwaan: A Dish with One Spoon reconsidered. *Ontario History, 112*(2), 191–210. https://doi.org/10.7202/1072237ar

Jardine, T. D. (2019). Indigenous knowledge as a remedy for shifting baseline syndrome. *Frontiers in Ecology and the Environment*, *17*(1), 13–14. https://doi.org/10.1002/fee.1991

Jessen, T. D., Ban, N. C., Claxton, N. X., & Darimont, C. T. (2022). Contributions of Indigenous Knowledge to ecological and evolutionary understanding. *Frontiers in Ecology and the Environment*, *20*(2), 93–101. https://doi.org/10.1002/fee.2435

Kakoty, S. (2018). Ecology, sustainability and traditional wisdom. *Journal of Cleaner Production*, *172*, 3215–3224. https://doi.org/10.1016/j.jclepro.2017.11.036

Kimmerer, R. W. (2015). *Braiding sweetgrass: Indigenous wisdom, scientific knowledge and the teachings of plants*. Milkweed.

Kusabs, I. A., & Quinn, J. M. (2009). Use of a traditional Maori harvesting method, the tau kōura, for monitoring kōura (freshwater crayfish, *Paranephrops planifrons*) in Lake Rotoiti, North Island, New Zealand. *New Zealand Journal of Marine and Freshwater Research, 43*(3), 713–722. https://doi.org/10.1080/00288330909510036

Latchmore, T., Schuster-Wallace, C. J., Longboat, D. R., Dickson-Anderson, S. E., & Majury, A. (2018). Critical elements for local Indigenous water security in Canada: a narrative review. *Journal of Water and Health, 16*(6), 893–903. https://doi.org/10.2166/wh.2018.107

Latulippe, N., & 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. https://doi.org/10.1016/j.cosust.2019.10.010

Lepofsky, D., & Caldwell, M. (2013). Indigenous marine resource management on the Northwest Coast of North America. *Ecological Processes*, *2*, Article 12. https://doi.org/10.1186/2192-1709-2-12

Little Bear, L. (2000). Jagged worldviews colliding. In M. Battiste (Ed.), *Reclaiming Indigenous voice and vision* (pp. 77–85). UBC Press. https://doi.org/10.59962/9780774853170-009

Ludwig, D., & El-Hani, C. N. (2020). Philosophy of ethnobiology: Understanding knowledge integration and its limitations. *Journal of Ethnobiology, 40*(1), 3–20. https://doi.org/10.2993/0278-0771-40.1.3

Maracle, S. R., Tournayre, O., Windle, M. J. S., Cormier, E., Schwartz, K., Wylie-Arbic, M., Rundle, E., Perron, M. A., Francis, A., & Lougheed, S. C. (2024). Nearshore fish diversity changes with sampling method and human disturbance: Comparing eDNA metabarcoding and seine netting along the Upper St. Lawrence River. *Journal of Great Lakes Research*, *50*(3), Article 102317. https://doi.org/10.1016/j.jglr.2024.102317

Maxwell, K. H., & Penetito, W. (2007). How the use of rāhui for protecting taonga has evolved over time. *MAI Review*, *2*, 1–15. https://journal.mai.ac.nz/maireview/article/686

McAllister, T., Hikuroa, D., & Macinnis-Ng, C. (2023). Connecting science to Indigenous Knowledge: Kaitiakitanga, conservation, and resource management. *New Zealand Journal of Ecology, 47*(1), Article 3521. https://doi.org/10.20417/nzjecol.47.3521

McCartney, A. M., Head, M. A., Tsosie, K. S. Sterner, B., Glass, J. R., Paez, S., Geary, J., & Hudson, M. (2023). Indigenous peoples and local communities as partners in the sequencing of global eukaryotic biodiversity. *npj Biodiversity, 2*, Article 8. https://doi.org/10.1038/s44185-023-00013-7

McMillan, L. J., & Prosper, K. (2016). Remobilizing *netukulimk*: Indigenous cultural and spiritual connections with resource stewardship and fisheries management in Atlantic Canada. *Reviews in Fish Biology and Fisheries, 26*, 629–647. https://doi.org/10.1007/s11160-016-9433-2

Mervis, J. (2023, October 25). Can Indigenous knowledge and Western science work together? New center bets yes. *ScienceInsider.* https://www.science.org/content/article/can-indigenous-knowledge-and-western-science-work-together-new-center-bets-yes

Morrison, B. P. (2019). Chronology of Lake Ontario ecosystem and fisheries. *Aquatic Ecosystem Health and Management, 22*(3), 294–304. https://doi.org/10.1080/14634988.2019.1669377

Pauly, D. (1995). Anecdotes and the shifting baseline syndrome of fisheries. *Trends in Ecology & Evolution*, *10*(10), 430. https://doi.org/10.1016/S0169-5347(00)89171-5

Pauly, D., Christensen, V., Dalsgaard, J., Froese, R., & Torres, Jr., F. (1998). Fishing down marine food webs. *Science*, *279*(5352), 860–863. https://doi.org/10.1126/science.279.5352.860

Peltier, C. (2018). An application of Two-eyed Seeing: Indigenous research methods with participatory action research. *International Journal of Qualitative Methods*, *17*(1), 1–12. https://doi.org/10.1177/1609406918812346

Pierotti, R. (2010). *Indigenous knowledge, ecology, and evolutionary biology*. Routledge. https://doi.org/10.4324/9780203847114

Quaempts, E. J., Jones, K. L., O'Daniel, S. J., Beechie, T. J., & Poole, G. C. (2018). Aligning environmental management with ecosystem resilience: A First Foods example from the Confederated Tribes of the Umatilla Indian Reservation, Oregon, USA. *Ecology & Society, 23*(2), Article 29. https://doi.org/10.5751/ES-10080-230229

Ransom, J. W., & Ettenger, K. T. (2001). 'Polishing the Kaswentha': A Haudenosaunee view of environmental cooperation. *Environmental Science & Policy, 4*(4–5), 219–228. https://doi.org/10.1016/S1462-9011(01)00027-2

Reid, A. J., Carlson, A. K., Creed, I. F., Eliason, E. J., Gell, P. A., Johnson, P. T. J., Kidd, K. A., MacCormack, T. J., Olden, J. D., Ormerod, S. J., Smol, J. P., Taylor, W. W., Tockner, K., Vermaire, J. C., Dudgeon, D., & Cooke, S. J. (2019). Emerging threats and persistent conservation challenges for freshwater biodiversity. *Biological Reviews of the Cambridge Philosophical Society, 94*(3), 849–873. https://doi.org/10.1111/brv.12480

Sheridan, J., & Longboat, R. "He C. the S." D. (2006). The Haudenosaunee imagination and the ecology of the sacred. *Space and Culture*, *9*(4), 365–381. https://doi.org/10.1177/1206331206292503

Smith, L. T. (2021). *Decolonizing methodologies: Research and Indigenous Peoples* (3rd ed.). Bloomsbury.

Sodhi, N. S., & Erlich, P. R. (Eds.). (2010). *Conservation biology for all.* Oxford University Press.

Soga, M., & Gaston, K. J. (2018). Shifting baseline syndrome: Causes, consequences, and implications. *Frontiers in Ecology and the Environment, 16*(4), 222–230. https://doi.org/10.1002/fee.1794

Stoffle, R. W., Toupal, R., & Zedeño, N. (2003). Landscape, nature, and culture: A diachronic model of human-nature adaptations. In H. Selin (Ed.), *Nature across cultures: Views of nature and the environment in non-Western cultures,* (pp. 97–114). Springer. https://doi.org/10.1007/978-94-017-0149-5_5

Tynan, L. (2021). What is relationality? Indigenous knowledges, practices and responsibilities with kin. *Cultural Geographies, 28*(4), 597–610. https://doi.org/10.1177/14744740211029287

Wilson, N. J., & Inkster, J. (2018). Respecting water: Indigenous water governance, ontologies, and the politics of kinship on the ground. *Environment and Planning E: Nature and Space, 1*(4), 516–538. https://doi.org/10.1177/2514848618789378

Wilson, S. (2008). *Research is ceremony: Indigenous research methods*. Fernwood Publishing.

World Wildlife Fund [WWF]. (2024). *Living planet report 2024—A system in peril.* https://livingplanet.panda.org/en-US/

Wright, A. L., Gabel, C., Ballantyne, M., Jack, S. M., & Wahoush, O. (2019). Using Two-Eyed Seeing in research with Indigenous people: An integrative review. *International Journal of Qualitative Methods, 18*, 1–19. https://doi.org/10.1177/1609406919869695