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Received: 21 November 2020 | Accepted: 29 January 2021

DOI: 10.1002/pan3.10194

RESEARCH ARTICLE

PEOPLE AND NATURE | BRITISH ECOLOGICAL SOCIETY

The role of western-based scientific, Indigenous and local knowledge in wildlife management and conservation

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Funding information
Genome British Columbia, Grant/Award Number: 242RTE; Natural Sciences and Engineering Research Council of Canada, Grant/Award Number: PGSD2-534299-2019; Genome Canada, Grant/Award Number: 242RTE

Handling Editor: André Mascarenhas

Abstract

1. Managers of wildlife are faced with decisions and issues that are increasingly complex, spanning natural and human dimensions (i.e. values, preferences, attitudes). A strong evidence base that includes multiple forms and sources of knowledge is needed to support these complex decisions. However, a growing body of literature demonstrates that environmental managers are far more likely to draw on intuition, past experience or opinion to inform important decisions rather than empirical evidence.
2. We set out to assess how decision-makers and other potential knowledge users (a) perceive, evaluate and use western-based scientific, Indigenous and local knowledge and (b) the extent to which social, political and economic considerations challenge the integration of different forms of evidence into decision-making. In 2018, we interviewed members from natural resource management branches of Indigenous governments ($n = 4$) and parliamentary governments ($n = 33$), as well as representatives from nongovernmental stakeholder groups ($n = 28$) involved in wildlife management and conservation in the Canadian province of British Columbia.
3. Contrary to studies that suggest evidence-based conservation and management are rare, respondents described relying heavily on multiple forms of knowledge. Results revealed that western science is used near-unanimously, procured from internal (i.e. institutional) sources slightly more than external ones (i.e. peer-reviewed journals, management agencies in other jurisdictions). However, we found Indigenous and local knowledge use to be much less than western scientific knowledge (approximately half as much) despite being highly valued. Perceived challenges to applying Indigenous and local knowledge include a lack of trust, hesitancy to share knowledge (particularly from Indigenous communities), difficulties in assessing reliability and difficulties discerning knowledge from advocacy.
4. Despite high (and relatively diverse) evidence use, more than 40% of respondents perceived a diminishing role for evidence in final decisions concerning wildlife management and conservation. They associated this with decreases in institutional resources and capacity and increases in socio-economic and political interference.

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5. We encourage transformative change in wildlife management enabling decision-makers to draw upon multiple forms of knowledge. This transformative change should include direct involvement of knowledge holders, co-assessment of knowledge and transparency in how (multiple forms of) evidence contribute to decision-making.

KEYWORDS

co-assessment, evidence complacency, evidence-based conservation, fish and wildlife management, Indigenous and local knowledge, knowledge-action gap, knowledge exchange, natural resource management

1 | INTRODUCTION

Managers of wildlife (free-ranging, non-domestic animals) are faced with decisions and issues that are increasingly complex (Arlinghaus et al., 2015; Powell, 2020). This is especially true given the ecological crisis that is upon us, which includes pervasive and escalating threats to wildlife populations from a wide range of sources. For example, the UN body, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), has recently assessed the global extent of this crisis, finding that up to one million species of animals and plants are at risk of extinction in the short term (Balvanera et al. 2020; Díaz et al. 2019; IPBES, 2019a, 2019b). The cumulative and interacting drivers of these changes such as exploitation of organisms, climate change, pollution, invasion of alien species, etc., pose a particular challenge for already complex wildlife management and conservation.

Wildlife management and conservation involves managing wildlife, their habitat and the people who engage and interact with animals and ecosystems. Such efforts require engagement with not only conventional user groups, such as hunters and anglers, but also anyone with a vested interest in a wildlife issue, programme, action or decision. This reflects the need to integrate human dimensions of wildlife into management (i.e. values, decisions, actions, preferences, attitudes) from an array of increasingly diversified actors (i.e. resource-user groups, industry, private landowners, farmers, policymakers, conservation organizations and other stakeholders and rightsholders) with high expectations for involvement in the process (Decker et al., 2012; Riley et al., 2002). Thus, wildlife managers must not only consider the complex biological and ecological context of the decisions they make but also complex political, social and economic circumstances and influences. This vast social and ecological complexity is key for understanding how wildlife managers use evidence and make decisions, and vice versa.

Evidence-based decision-making is seen by many as an important tool for managing social-ecological complexity (Addison et al., 2016; Pullin & Knight, 2003; Sutherland et al., 2004). Evidence is important for both understanding complex interactions, and for politically justifying policy and management decisions (Adams & Sandbrook, 2013; Pielke, 2007). Moreover, the centrality of evidence to making and legitimizing decisions is prompting researchers and practitioners to consider multiple forms and sources of knowledge (Reed et al., 2013; Salafsky et al., 2019; Tengö et al., 2014). Specifically, in environmental management, there is a growing interest and emphasis to incorporate a broad range of knowledge types including Indigenous and local knowledge (ILK) alongside the foundations of western-based science (Reyes-García & Benyei, 2019; Thompson et al., 2020; Wheeler et al., 2020; Wheeler & Root-Berenstein, 2020).

However, there are indications that the rhetorical popularity of evidence-based management is not matched in practice. For example, numerous studies have shown that environmental managers are far more likely to draw on intuition, past experience or opinion to inform important decisions rather than evidence derived from western-based science (e.g. see review in Kadykalo et al., 2021; Cook et al., 2010; Fabian et al., 2019; Matzek et al., 2014; Pullin et al., 2004; Young & Van Aarde, 2011). This is described as 'evidence complacency' (Sutherland & Wordley, 2017) in which despite the availability of evidence, it is not sought or used to make decisions. Even less is known about the use of more informal and tacit types of knowledge such as ILK. However, Lemieux et al. (2018) recently revealed that in Canada's protected areas organizations, ILK is also valued and used less than personal and institutional experiential knowledge.

These studies suggest that the creation of knowledge and collection of evidence are necessary but not sufficient criteria for enacting evidence-informed decision-making. A growing research field, so-called 'knowledge exchange', has been focusing on how knowledge is exchanged and mobilized, and with whom it is exchanged (Cvitanovic et al., 2016; Fazey et al., 2012; Reed et al., 2014). This literature insistently emphasizes the need for knowledge and knowledge generators to be, or perceived as, salient (relevant and timely), credible and legitimate to enable effective knowledge exchange (see Cash et al., 2003; Cook et al., 2013). However, effective knowledge exchange requires determining, first and foremost, how (sometimes competing) knowledge is used, perceived and evaluated by potential users. While this seems like a logical and obvious objective for those studying knowledge exchange, it has not often been explored empirically (Tengö et al., 2017; Young et al., 2016).

The characteristics of knowledge and knowledge-holders notwithstanding, the use of knowledge is also dependent on the intense

political, social or economic considerations faced by potential knowledge users. Some of these considerations may constrain, compromise and interfere with the ability of wildlife managers to make decisions based on evidence. Notably, limited financial resources, lack of staff and inadequate timeframes are significant barriers to knowledge use in both western (Lemieux et al., 2018; Westwood et al., 2017; Young et al., 2016) and Indigenous (Ban et al., 2018) environmental management agencies. Indeed, these challenges have already been well documented in our study area, the province of British Columbia in Canada. For example, a survey of 403 provincial government scientists found the majority (71%) said they had witnessed a decrease in research capacity in their ministry and/or branch over the course of their tenure in BC government; and 68% believe that there are insufficient resources to effectively fill their branch or ministerial mandate (Smith et al., 2017). It is also telling that 57% of government scientists believed that public service cuts compromise the government's ability to use the best available evidence in decision-making, and that 49% believed political interference has compromised their ability to develop laws, policies and programmes based on evidence.

While we delineate, western-based scientific knowledge, Indigenous knowledge and local knowledge for this article, we also recognize that the differences among these knowledge types fall along, at best, a fuzzy spectrum. This delineation is an artificial construct and risks oversimplifying knowledge systems that are diverse, complex and increasingly intertwined. Indeed, ILK (Ban et al., 2018; Díaz et al., 2015; Tengö et al., 2017) shares many similarities with western-based scientific knowledge (i.e. learning by doing, building and organizing knowledge). However, delineations play a necessary role in facilitating evaluation of knowledge, which occurs primarily within, rather than across knowledge systems (Alexander et al., 2019; Tengö et al., 2014). It is important to consider the differences among these knowledges and their approaches may not be only related to the different data or information themselves but also possibly with different understandings of how management should proceed. Overlooking these differences can hinder collaborative arrangements among western, Indigenous and local governments and communities.

Using western-based scientific knowledge, ILK individually or synergistically can yield complementary insights that can enrich and enhance our collective understanding of the natural world (Ban et al., 2018; Tengö et al., 2014). ILK can provide valuable information from long-term ecological monitoring to inform conservation goals and adaptive management, especially in data-poor scenarios. For example, Indigenous knowledge such as current and historical estimates of fish body size and abundance extended baselines for data-poor species such as yelloweye rockfish in British Columbia, Canada (Eckert et al., 2018). Local knowledge from recreational anglers and spear fishers in Galicia, Spain provided valuable data for management on the temporal declines of targeted species such as cephalopods and finfish stocks but also on non-target keystone species such as the poor status of kelp beds which support these coastal ecosystems (Pita et al., 2020).

Although there is an expanding interest from the western governments and institutions in engaging with ILK holders (Simpson, 2004; Wheeler et al., 2020), there are significant barriers to meaningful inclusion of Indigenous and local views and knowledge. Such issues include, for example, the perceived need to 'validate' ILK with western-based science; the low level of knowledge-holder inclusiveness; the amount of time required to build relationships and gather knowledge; and the blatant disrespect or ignorance of Indigenous rights (Ban et al., 2018; Reyes-García & Benyei, 2019; Wheeler et al., 2020; Wong et al., 2020). The extraction of Indigenous knowledge, in particular, for use by western decision-makers may be problematic and work to further settler colonialism, especially if subsequent decisions are made without the full involvement, collaboration and consent of the Indigenous and local communities themselves. This can lead to the marginalization, appropriation and commodification of Indigenous knowledge (Simpson, 1999, 2001).

The mountainous province of British Columbia (BC), Canada makes for a relevant case to explore the role of well-informed decision-making to enhance social-ecological resilience. BC is rich in natural resources contributing substantially to the local and national economies. It is also home to ethnically and culturally diverse people (Indigenous peoples with traditional and constitutional rights, European and Asian immigrants, engaged resource-user groups). The province is experiencing rapid biophysical changes to its highly diverse ecosystems impacting tightly linked social-ecological systems. Climate-driven hydrological changes (e.g. increased summer freshwater temperatures, more hypoxic lakes; reduced snowpack; earlier onsets of spring snowmelt) are a primary concern (Healey, 2011; Islam et al., 2017; Zwiers et al., 2011). Meanwhile, BC's boreal forests have suffered extreme wildfire seasons and a severe mountain pine beetle *Dendroctonous ponderosae Hopkins* outbreak (Dhar et al., 2016; Kirchmeier-Young et al., 2019). These vulnerable habitats support charismatic at-risk wildlife species of major significance to Indigenous and non-Indigenous people alike such as cutthroat *Oncorhynchus clarkii* and bull trout *Salvelinus confluentus*, and mountain caribou *Rangifer tarandus*. Moreover, they support social, cultural and economic well-being of BC's people in the form of, for example, water supply, subsistence and recreational fisheries and hunting, wild foods, sense of place, cultural identity and heritage.

The goal of this paper is to provide an initial assessment of the extent to which Indigenous, local and western-based scientific knowledge are incorporated into wildlife management in BC. We used semi-structured interviews to assess how these different knowledges are (a) perceived, evaluated and used by potential knowledge users—Indigenous governments, parliamentary governments and stakeholders and (b) the extent to which social, political and economic considerations challenge the integration of evidence into decision-making. In (a), perceptions and evaluations apply to the knowledge generators (i.e. holders) by extension also. While we have attempted to have a representative dataset, we acknowledge our data are biased overwhelmingly to parliamentary government or NGO decision-makers and this assessment is therefore most reflective of how these different knowledges are used by non-Indigenous

and non-local decision-makers. We explore this using the case of managed rainbow trout *Oncorhynchus mykiss* fisheries in BC. This effort to gain a better understanding of how knowledge is perceived, evaluated and used will hopefully lead to a stronger and more diverse evidence base and in turn, more informed decision-making based on multiple ways of knowing.

1.1 | The case

The near-ubiquitous range of rainbow trout in BC is managed through a complex combination of provincial and federal government agencies and processes. Indigenous communities and governments also manage rainbow trout in certain territories. Additionally, stakeholders (e.g. academic researchers, non-profit organizations, private consultants, resource user groups) are also important actors in the conservation and management of rainbow trout in BC.

In Canada's parliamentary governments, conservation and management of freshwater fish is a provincial responsibility while marine fish are a federal responsibility. The British Columbia Ministry of Forests, Lands, and Natural Resource Operations and Rural Development (FLNRORD), hereafter 'provincial natural resources ministry', is the primary responsible agency for management of wild freshwater populations of rainbow trout. Provincial wildlife management is divided into nine resource management regions to cover all areas of the province. Management depends on a range of individual actors in different roles: multiple Biologists per region, classified by their area of focus (ecosystem, fish/fisheries, stock assessment, aquatic, stream, lakes, riparian, habitat, wildlife, etc.); Fish and Wildlife Section Heads (usually one per region) are responsible for fisheries and wildlife programme management for a specific region; Directors of Resource Management (usually one per region) which oversee programmes related to wildlife but also programmes related to ecosystems, habitat management, forest policy and practices, land use planning, etc. In addition, resource management regions are to varying extents supported, coordinated and directed by Central Management in the provincial capital, Victoria, which also has specialized Biologists, and Directors for each broad area of focus (e.g. Fish and Wildlife, Fisheries, Fish and Aquatic Habitat). Central Management also has several unique actors (e.g. regulations and policy analysts, human dimensions specialists). Deputy Ministers within the provincial natural resources ministry are senior civil servants responsible for the ministry's day-to-day operation, budget and programme development. The provincial natural resources ministry also receives scientific and resource support in management from the British Columbia provincial Ministry of Environment (MOE) primarily from research specialists. Wildlife management decisions (e.g. fishing and hunting regulations, stocking hatchery fish) in BC are made by dedicated provincial natural resources ministry staff (statutory decision-makers [SDMs]; notably, Deputy Ministers, Directors and Section Heads) possessing statutory (compliance and permitting) decision-making authorities under legislation. Decisions by SDMs are purportedly evidence-based on the best available science (Government of British Columbia, 2017), similar to other wildlife management agencies across North America (see Artelle et al., 2018).

Today, many Indigenous communities and governments manage Indigenous and non-Indigenous recreational and subsistence fisheries on their reserve lands and beyond. Over the vast majority of BC, colonial immigrants settled on land for which Indigenous title had not been ceded or negotiated. The Dominion of Canada and provincial governments undertook a joint process in BC that imposed a very small reserve for each of the many First Nation (Indigenous) communities (Harris, 2008). The small reserve allotment process (only slightly more than one-third of 1% of the land areas in the province) was designed on the erroneous assumption that Indigenous peoples in the province were primarily fishing peoples and did not require a large land base to maintain their livelihoods (Ibid.). The British Columbia Assembly of First Nations (https://www.bcafn.ca/) and the First Nations Fisheries Council of British Columbia (https://www.fnfisheriescouncil.ca/) are working in partnership with the Canadian and BC governments to advance true and lasting reconciliation, towards more meaningful implementation of rights-based fishing opportunities and management of fisheries on asserted traditional territories (beyond the small reserves allotted during colonization).

In BC, myriad stakeholders wield great influence on the conservation and management of rainbow trout. Many of the lakes within BC do not naturally support fish populations due to a lack of spawning habitat or other limitations, meaning that populations are maintained by annual stocking. The Freshwater Fisheries Society of British Columbia (FFSBC; https://www.gofishbc.com) is a private non-profit organization contracted by the provincial natural resources ministry to deliver the provincial fish stocking programme and to offer a range of conservation services (i.e. outreach activities, education) to protect wild fish by diverting recreational angler pressure to hatchery-raised fish. BC Hydro (https://www.bchydro.com), a province-owned electric utility, is a unique actor that has a major water and land footprint in BC. Wildlife mitigation (e.g. fish spawning/bird nesting/migratory bird habitat protection; fish salvage) and monitoring is conducted by BC Hydro in watersheds impacted by their dams, primarily the Kootenay, Columbia and Peace rivers. Local environmental non-governmental organizations (ENGO) also play an important role as stakeholders and advisors to provincial and regional wildlife conservation and management. For example, BC Wildlife Federation (https://bcwf.bc.ca) and BC Conservation Foundation (https://bccf.com) generally aim to ensure the long-term sustainability of BC's fish, other wildlife and outdoor recreational resources; The Habitat Conservation Trust Foundation (https://hctf.ca) receives surcharge income from hunting, fishing, trapping and guide-outfitter licenses per BC legislation and in turn funds conservation projects on freshwater fish, other wildlife and the habitats in which they live; end-user special-interest groups (e.g. BC Federation of Fly Fishers https://www.bcfff.bc.ca, BC Fishing Resort & Outfitters Association http://bcfroa.ca, The British Columbia Federation of Drift Fishers https://www.bcfdf.com, The Steelhead Society of British Columbia http://www.steelheadsociety.org) also work towards issues on fisheries

conservation and quality fishing opportunities. Many private environmental consultants are contracted throughout the province by federal, provincial and Indigenous governments to conduct research on wildlife issues. Many academic researchers in BC and even across North America also work closely with federal, provincial, Indigenous governments and FFSBC—in research partnerships and collaborations on wildlife and habitat issues or simply act as advice providers. Retired provincial government employees are also important actors, providing a unique perspective on wildlife issues and many are still active within this area as, for example, members or employees in ENGOs described above, fishing guides, issue advocates, informal government advisors.

2 | METHODS

This research is exploratory, aimed at investigating and categorizing how decision-makers and other potential knowledge users involved in the conservation and management of wildlife within British Columbia view and use various types of knowledge (i.e. Indigenous, local and western-based scientific). As such, this research is intended to be primarily descriptive, and hypothesis-generating rather than hypothesis-testing. The data reported in this article were collected as part of a broader study entitled '*Sustaining Freshwater Recreational Fisheries in a Changing Environment*' that aims to develop conservation genomic tools and policy recommendations to help manage and preserve the genetic diversity of rainbow trout. The study objective is to support and sustain healthy populations of rainbow trout and the recreational fishery that depends on them.

Befitting exploratory research, we developed and employed an interview schedule using open-ended questions (Axinn & Pearce, 2006; Creswell, 2014; Young et al., 2018). Open-ended questions allowed a wide range of respondents to explain their positions, priorities and opinions freely. It also allows them to be precise in their answers, providing hard to obtain and sensitive information on evidence use and decision-making processes. The set of questions analysed in this article are provided in Table 1 and a copy of the interview schedules (questionnaires) are provided in the supporting information. This study was conducted in accordance to the University of Ottawa Research Ethics Board (File Number: 02-18-08). All participants gave informed consent to participate in the study. A copy of the consent form is in the supporting information. We performed a pilot interview after ethical clearance that showed no issues. Qualitative data were transcribed from audio to text using Trint (https://trint.com) and analysed using NVivo 12 software (QSR International Pty Ltd., 2018). For open-ended responses, a three-step inductive coding process was applied to qualitative data (Thomas, 2006). First, responses were read to identify keywords, which became a list of potential codes. Similar potential codes were then grouped into themes. Responses were read a second time and sorted under these themes to provide a measure of their prevalence. A response may have multiple thematic codes if warranted. All coding was performed by the first author. The codebook is available in the supporting information. For details on the development of the interview population frame, see Kadykalo et al. (2020). A total of $N = 161$ individuals or organizations were contacted to request an interview.

A total of 65 interviews (response rate of 40%) were conducted in-person ($N = 43$) and over the phone ($N = 22$) between April and November 2018 divided between three broad groups: members from natural resource management branches of Indigenous governments ($N = 4$), and parliamentary governments ($N = 33$), as well as representatives from non-governmental stakeholder groups ($N = 28$) involved in the management of recreational and subsistence rainbow trout fisheries in BC. The affiliations of respondents are

TABLE 1 Open-ended interview questions analysed in this article

Question	Audience
Does Indigenous and/or local knowledge or information play a role in your work?	All
If yes, how important are these different types of knowledge or information to your work?	
If yes, in what ways do you use these different types of knowledge or information in your work?	
Does western scientific knowledge or information play a role in your work?	All
If yes, how important is western scientific knowledge or information to your work?	
If yes, in what ways do you use western scientific knowledge or information in your work?	
What role (if any) does western scientific knowledge or information or data play in your decision-making (in a typical fishing season)?	Parliamentary governments
In your opinion, what role (if any) does western scientific knowledge or information or data play in current provincial fisheries decision-making (i.e. in the Ministry of Forest, Lands and Natural Resource Operations and Rural Development and Environment)?	Indigenous governments, Stakeholders
Has the role of evidence-based management changed over time within the relevant provincial ministries? Do you think fisheries decisions are more likely to be influenced by social, political and/or economic interests today than they were historically? If so, why?	All
Generally speaking, in your opinion what makes knowledge about rainbow trout 'reliable' or 'unreliable'? (What are the characteristics of 'reliable' and 'unreliable' knowledge?)	All

TABLE 2 Affiliations of the 65 participants and 96 non-participants (who were contacted but did not participate because they (a) did not respond to our request, or (b) declined to participate), grouped as members from natural resource management branches of Indigenous governments, and parliamentary governments, as well as stakeholders

Indigenous governments (FN)	*N*	Parliamentary governments (GOV)	*N*	Stakeholders (STKH)	*N*	Total *N*
Biologists	2	Biologists (FLNRORD)	17	Academia	6	
Fisheries managers	2	Directors (FLNRORD)	3	BC Hydro	2	
		Fish & Wildlife Section Heads (FLNRORD)	6	Environmental non-governmental organization (ENGO)	5	
		Human Dimensions Specialist (FLNRORD)	1	Freshwater Fisheries Society of BC (FFSBC)	6	
		Policy Analysts (FLNRORD)	2	Private environmental consultants	6	
		Conservation Science Section (MOE)	3	Retired provincial government employees	3	
		Science Branch (DFO)	1			
Participant sub-total	(4)		(33)		(28)	65
Biologists	2	Assistant Deputy Minister (FLNRORD)	3	Academia	4	
Fisheries managers	19	Biologists (FLNRORD)	31	BC Hydro	2	
		Directors (FLNRORD)	10	ENGO	2	
		Fish & Wildlife Section Heads (FLNRORD)	2	FFSBC	7	
		Fisheries Advisor	1	Private environmental consultants	1	
		Managers (FLNRORD)	2			
		Permit Clerks (FLNRORD)	3			
		Policy Analyst (FLNRORD)	1			
		Policy Leads (FLNRORD)	2			
		Regulations Officers (FLNRORD)	1			
		Regional Resource Manager (DFO)	1			
		Science Branch (DFO)	1			
		Provincial Fish Science Specialist (Government of Alberta)	1			
Non-participant sub-total	(21)		(59)		(16)	96
Total	25		92		44	161

provided in Table 2. While the focus of this research is recreational rainbow trout fisheries, many of the respondents are involved in the conservation and management of fish and other wildlife populations. Therefore, the responses in this article are most specific to fisheries management but are described throughout under the broader term 'wildlife management and conservation'. Interviews lasted between 18 min and 2 hr, depending on the level of detail provided by the respondent.

3 | RESULTS

The results are organized by the order of questions in Table 1. Respondent sources and illustrative quotations which support our results are provided in Appendix A (Supporting Information) and linked as citations (end-noted superscripted numbers).

3.1 | Indigenous and local knowledge

3.1.1 | Indigenous knowledge

Indigenous knowledge plays a distinct role in the work for 51% of respondents[1] (i.e. they use it on a day-to-day basis), a minimal or limited role for 9% of respondents[2] and no distinct role for 22% of respondents[3] (Figure 1). For 23% of respondents, Indigenous knowledge was openly described as important, even critical, to their work.[4]

The use of Indigenous knowledge was categorized in multiple different ways (Table 3). Many respondents cited statutory and legal (and funding agency) obligations to engage Indigenous peoples in decision-making and consider Indigenous knowledge more strongly.[5] Although, as some respondents noted, much of these obligations are just 'paid lip service', lacking action—'it's very early days for us around that now'.

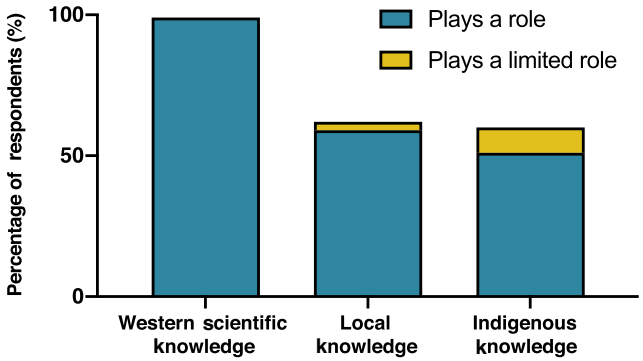

FIGURE 1 The role of western scientific, local and Indigenous knowledge, as measured by percentage, in the work of $n = 65$ respondents

Parliamentary government employees and stakeholders cited challenges and struggles in both *getting* and then *incorporating* Indigenous knowledge into decision-making.[6] The reason for these challenges was attributed to two issues: confidentiality of Indigenous knowledge and lack of trust. Examples for the former,

> They like to protect it [Indigenous knowledge]. They often don't like to share it. (Interview #58; male; provincial natural resources ministry affiliation).

> There may be a reluctance on the First Nations part to provide it. First Nations are probably going to be more and more reluctant to divulge anything on net fisheries because they're going to be afraid that they're going to be cut back. (Interview #59; male; ENGO affiliation).

Examples for the latter,

> It's a process where we have to gain the trust of the First Nations before we get there. The First Nations [Indigenous knowledge]; that's probably the most important knowledge to gain because when we're dealing with accommodation, it'll be very important to gain the trust and to begin to work together, especially where they're beginning to say particular fisheries are now sustenance fisheries. (Interview #14; male; provincial natural resources ministry affiliation).

> I think we struggled sometimes understanding what was really important to First Nations and incorporating it. Sometimes it was the trust factor in terms of actually getting the particular traditional knowledge. (Interview #53; male; retired provincial government employee affiliation).

Confidentiality of Indigenous knowledge and a lack of trust may be a (by)-product of (perceived) insufficient legal protection of intellectual property.[7] It may also be due to a perceived concern of further losing constitutional (i.e. hunting and fishing) rights.

Several respondents (from the provincial natural resources ministry, ENGOs, the province-owned electric utility) acknowledged that the role of Indigenous knowledge is less than it should be, and a better job should be done in reflecting Indigenous values and knowledge in modern wildlife decision-making.[8]

3.1.2 | Local knowledge

Local knowledge plays a role in the work of 59% of respondents[9] and a minor or minimal role for 3% of respondents[10] (Figure 1). In all, 12 respondents (19%) were definitive on the importance of local knowledge to their work, relying heavily upon it.[11]

Descriptions of local knowledge use by parliamentary government and stakeholder respondents overwhelmingly focused on the value of local knowledge from local communities (e.g. resource users groups) identifying blind spots (Table 3). That is, parliamentary government management agencies are limited by time and resources across (seemingly) endless territories ('we have so many lakes. I don't know a lot about all of them'), and therefore rely on local knowledge to 'put up red flags'. Moreover, like Indigenous knowledge, a sample of responses focused specifically on local knowledge signalling where and when environmental changes are occurring, and how local knowledge is used as a tool to inform and prioritize work and issues. For example,

> It's sad to say but we're pretty reactionary in our work. I'd say for the changes we make, probably 50 percent of them are driven by initial comments from public or other user groups that trigger us to go and take a closer look. Then we can make an informed decision after we gather some data. (Interview #18; male; provincial natural resources ministry affiliation).

Some respondents noted that resource user groups—through sharing of local knowledge—have significant influences in prioritizing issues and projects or can be vital allies in conservation causes.[12] Conversely, some respondents left a cautionary note on incorporating stakeholder information.[13] It was remarked that anglers (and other local knowledge holders) may not be able to scale their individual observations and experiences to population-level understanding (i.e. unaware of the cumulative impacts of what they and others are doing to fish populations broadly—e.g. mortality associated with catch-and-release fishing). Because local knowledge is frequently used for lobbying (i.e. politicized), it has the potential to steer management in wrong or self-interested directions.[14] Therefore, local knowledge may be weighted more heavily when it aligns with the core objectives of management[15] and can be confrontational if it conflicts with the core objectives of management.[16]

TABLE 3 Indigenous, local and western scientific knowledge used as evidence in the work of $n = 65$ respondents. Raw counts (and %) are number of respondents making a mention to the corresponding use of evidence. Respondent sources and illustrative quotations which support evidence use are provided in Appendix A and linked as citations (end-noted superscripted numbers)

Evidence use	Examples	Indigenous knowledge	Local knowledge	Western scientific knowledge
Informing and re-fining work priorities and strategies Guide decisions, priorities, research and management actions	Where to prioritize enforcement, monitoring, etc.; which projects (e.g. research questions), populations, objectives (protection, angling regulations) and issues (e.g. disease, invasive species) to prioritize	9 (14%)[1]	12 (19%)[10,11]	45 (69%)[20]
Historical information on fish and fisheries The distribution and extent of native fish populations	Abundance, distribution, habitat, fish size, population size, population trends, occupancy, range, spawning locations, species composition, threats, etc.	24 (37%)[2]	10 (15%)[12]	
Identifying blind spots Issues or a sense of the quality or quantity of the resource people are seeing on the landscape	Angling pressure/over-fishing, disease, invasive species; population abundance/density		24 (37%)[13,14]	
Environmental change The value of knowledge in capturing *where* and *when* 'inflection points' or changes occurred or might be occurring	Angling pressure, catch rates, climate, fish size, habitat and flows, overfishing, extinctions/extirpations	9 (14%)[3,4]	7 (11%)[15]	
Consideration of proposed regulation changes Adjusting or setting regulations	Stocking plans and decisions		5 (8%)[16]	11 (17%)[21]
To inform historical baselines Historical and contemporary 'benchmarks'; what habitats *were* or *are* capable of in terms of fish and wildlife production	The ecological value or capacity of fish habitats prior to European colonialism or Post-World War II economic expansion	5 (8%)[5]	7 (11%)[17]	
Alternative Source of information A secondary source or perspective for comparison or supplementation of other knowledge types, 'even if it's just to confirm my own observations'	'Other data to substantiate' a knowledge claim	4 (6%)[6]	4 (6%)[18]	
Local communities/stakeholder values and preferences Cultural and material values and importance tied to fish and fisheries, and how communities and stakeholders would like them to be managed	Harvest preferences, preferred spawning habitats, prioritizing populations, scenery		13 (20%)[19]	
First Nations traditional use, values and preferences Cultural and material values and importance tied to fish and fisheries, and how First Nations would like them to be managed	Historic subsistence fisheries and practices	8 (12%)[7]		
Indigenous 'stewardship values' Advocacy, protection and restoration of fish populations and fish habitat	Protection of quantity and quality of fish	5 (8%)[8]		
Recovery plans and assessments	Historical abundance, historical distribution	2 (3%)[9]		

3.2 | The interface between Indigenous and local knowledge and management

Indigenous and local knowledge are grouped here not to conflate them, or to suggest they are interchangeable, but to best discuss the findings given these types of knowledge or information have not traditionally been the foundation or explicitly accounted for within the frameworks of western (i.e. parliamentary-governed) wildlife management.

Engaging ILK and then incorporating and reflecting it into modern wildlife management is being attempted or discussed[17] (by 45%), but actually doing it in practice is characterized as a challenge.[18] To summarize respondent perceptions, ILK is 'not really straightforward' and is difficult to understand, translate and assess. Additionally, while Indigenous governance systems are highly diverse—they may follow a very different decision-making process which may be very specific, consensus-driven and therefore

prolonged (i.e. multigenerational) by western standards.[19] These struggles notwithstanding, ILK faces an additional uphill battle as western science generally carries more weight in decision-making.[20] However, ILK can lead to valuable insights[21] that could lead to better decisions, harnessed via collaborations and partnerships[22] which are projected to increase[23] especially given the provincial government has emphasized ILK as a key resource.[24] When it comes to reconciling ILK with wildlife management, two-way dialogue[25] focused on respectfully unpacking party interests and long-term goals was recommended for building trustful relationships.[26]

3.3 | The interface between Indigenous and local knowledge and western scientific knowledge

Fundamentally, the philosophies between ILK and western science may not differ substantially.[27] Successful integration (merging and bridging) or coexistence of ILK with western-based science was seen as partially dependent on being open to individual positions and values—'if you're open to it then it'll diffuse, but if you're not and close to it, it won't resonate'.[28] While collaborative approaches to combine knowledge types in decision-making are evolving, involved and time-consuming, such approaches can reveal unique information.[29] Moreover, western science can complement ILK and add more weight to ILK, and vice versa.

3.4 | Western scientific knowledge

Respondents were near-unanimous that western scientific knowledge plays a role in their work and decision-making[30] (98%; Figure 1). The majority of respondents (65%) reported that western scientific knowledge plays a primary, central and fundamentally critical role in their work,[31] for example, 'that's mainly what we do', 'it's the foundation of our work' and 'it underpins all or our fisheries work in the province'. As the core of many respondents' work, western scientific knowledge was considered as the *most* important source of information for their work (e.g. 'the actual final decisions tend to be weighted around western science and all others feed into it'). However, two respondents (both Directors of Resource Management at the provincial natural resources ministry) were transparent that at their level of management, western scientific knowledge plays little role directly.[32]

Western scientific knowledge is used by the majority of respondents (69%) to guide decisions, priorities and management actions (Table 3); for example, evaluating projects and programs,[33] adjusting or setting regulations,[34] especially stocking rate protocols.[35] Several respondents noted that in addition to the obvious use of natural science, that increasingly human dimensions research (e.g. creel and preference surveys) are being applied to inform decisions.[36]

Western scientific knowledge used in decision-making is primarily sourced from 'in-house' 'evidence-producers'[37] (49%; e.g. stock and lake assessments,[38] monitoring programmes,[39] long-term experiments, academic partnerships) and 'external' secondary sources[40] (39%; e.g. peer-reviewed journals and publications, books, information from government management agencies in other jurisdictions). Several respondents clarified that they were not statutory decision-makers, and their roles were entirely about producing western scientific knowledge, and in cases, also providing advice (e.g. briefing notes) for decision-makers or stakeholders.[41]

3.5 | The diminishing role of evidence in the decision-making process

While evidence clearly has a considerable role in wildlife management and conservation—more than 40% of all respondents, namely, parliamentary government employees,[42] those that at one time were in the employ of the provincial government,[43] and those who work closely with parliamentary governments[44] provided accounts about what they perceived as the diminishing role of evidence (including ILK and western scientific knowledge) in decision-making. According to these accounts, evidence in decision-making is limited by increased political and socio-economic interference (28%),[45] decreased institutional resources and capacity (9%)[46] and science integrity (9%)[47] (Figure 2).

3.5.1 | Political and socio-economic interference

In the perspectives of many respondents, wildlife decisions may begin as evidence-based but are prone to becoming influenced by social, political and economic factors (e.g. values, ideology). In other words, management actions and policy decisions may deviate from

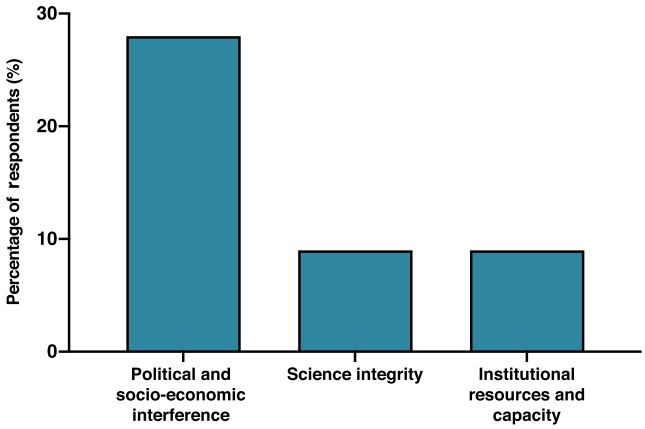

FIGURE 2 The diminishing role of evidence in provincial wildlife policy and practice due to increased political and socio-economic interference; reduced science integrity; and reduced institutional resources and capacity. Measured by percentage for $n = 65$ total respondents which specifically mentioned limitations to evidence-based decision-making

evidence. This is by no means a recent phenomenon but was described as more likely to occur today than it was some 10–25 years ago. Moreover, it was perceived that the higher within an organizational hierarchy evidence is considered in decision-making (e.g. at the Director or Deputy-Ministerial level), the more likely that evidence will be diluted. However, resource management decision-making was also frankly portrayed as a lot more complex today than yesteryear due to for example, a much more knowledgeable and better organized stakeholder base, especially around wildlife species which are targeted for recreation and harvest. This complexity may result in knowledge becoming politicized or exploited for social, political or economic objectives (e.g. delaying actions and decisions over scientific uncertainty). In sum, provincial government decision-making may not be 'purely science-based so much as its science-informed' (Interview #6; male; provincial natural resources ministry affiliation). Appendix B (Supporting Information) presents a sample of illustrative quotations which capture the issue of political and socio-economic interference to evidence-based decision-making.

3.5.2 | Institutional resources and capacity

Respondents submitted that while decisions are made on the best available evidence available to them, they are challenged to deliver science (i.e. conduct research and/or use evidence) by limited resources. For example,

> The provincial government that was in from 2001 to 2016 defunded the provincial natural resources ministry and de-staffed it by 50 percent. So like a distillation column, when you de-staff, a lot of the bright people leave and what you're left with is people that are close to retirement, insanely committed that they'll stay there no matter what, or the idiots who are just happy to have a job. (Interview #57; male; academia affiliation).

The result being a shift from being less 'research-driven' to more 'management-driven' in which decisions rely more heavily on anecdotal information, and 'managing by feel'. The resulting perception is that provincial ministries are no longer evidence producers (i.e. providers of western scientific knowledge) with academia fulfilling vacated parliamentary government science-based roles—for example,

> I think the universities today play a greater role in providing information than the provincial government does unfortunately. I think their role is flipped. Mostly they're a regulatory body now, unfortunately. They used to provide science-based information of their own but not so much anymore. (Interview #45; male; private environmental consultant affiliation).

3.5.3 | Science integrity

The integrity of parliamentary government western science was called into question by some respondents. When and where decisions are made by individuals (e.g. district managers) that lack experience and specific scientific education and training (e.g. statistics, social sciences, aquatic ecology) or there are few such qualified staff (that feed into the decision-making process), scientific integrity is perceived to suffer as decisions become based on feel and reaction opposed to analysis of data. The following example captures this limitation,

> The institutional knowledge is just a fraction of what it used to be. We have fewer people with long-term experiences and a lot of new staff not from BC. They're usually smart people. They work hard. They're biologists. But they start at ground zero with the history, geography, and biology of the province. (Interview #42; male; provincial Ministry of Environment affiliation).

3.6 | What is 'reliable' or 'unreliable' knowledge?

Appendix C (Supporting Information) presents the thematic codes—criteria—associated with 'reliable' and 'unreliable' knowledge along with the number of respondents making mention of each theme. Starting with reliability, a substantial minority of all groups mentioned the importance of factual corroboration of knowledge claims (e.g. by pictures, data, etc.; Table C.1). All groups also cited the importance of repeatability and reproducibility to demonstrate consistency, sound research design and methods, and peer-reviewed knowledge or information. Similar numbers across all groups also cite the scientific method, reputation—especially trustworthiness—of claimants, and quantifiable data as important indicators of reliable knowledge. Noticeable differences include a sizeable number of both parliamentary government employees and stakeholders citing the importance of acknowledging limitations (i.e. assumptions, uncertainty), as well as the expertise, skills, education and training of claimants. This was not as frequently mentioned by members from natural resource management branches of Indigenous governments. Conversely, members from natural resource branches of Indigenous governments cited the importance of publicly available knowledge and information. Unsurprisingly, parliamentary government employees also focused more on the personal 'hands-on' experience of claimants than other groups. Some respondents self-identified their own confirmation bias influencing perceptions of reliability, whereby knowledge claims which re-affirm previously existing experience and beliefs are given more weight.

Correspondingly, concerning unreliable knowledge, respondents frequently cited opinion, conjecture, or speculation without sufficient proof or evidence (Table C.2). Related to this, several responses described the 'Dunning-Kruger effect' (Dunning, 2011), a cognitive

bias in which people judge their cognitive ability to be greater than it is. Other key indicators of unreliable knowledge mentioned include issue advocacy or self-interest of claimants; poor or non-transparent research design and methods (particularly for grey literature which is 'not very well standardized, documented or reported'); and anecdotes, hearsay and inconsistency (i.e. conflicting reports, sampling bias). Stakeholders cited slightly fewer indicators of unreliable knowledge while members from natural resource branches of Indigenous governments cited none specifically.

While ILK itself was explicitly cited by a few respondents as unreliable (Table C.2), several respondents indicated that reliability of Indigenous knowledge was especially difficult to assess.[48] This becomes an issue for application according to some respondents if Indigenous knowledge cannot be assessed for reliability under the same kind of criteria and scrutiny as western scientific knowledge.[49] Although people embedded in Indigenous knowledge systems might disagree with this assertion, that Indigenous knowledge cannot be assessed for reliability to the same extent as western scientific knowledge (though it might be difficult to assess within a western framework). Other respondents were optimistic about the reliability of Indigenous knowledge, especially if assessed under the criterion of sound research design and methods, repeatability, reproducibility and consistency.[50]

Several respondents cited 'shifting baselines' (i.e. 'creeping normalcy'—Knowlton & Jackson, 2008; Pauly, 1995) as an important temporal interaction on determinations of reliable or unreliable knowledge.[51] Namely, the weight of historical knowledge may be diminished in contemporary contexts if major changes accepted as normal happen slowly through minor, often unnoticeable, increments of change.[52] Thus, reliability of knowledge may be dependent on the 'baseline condition', that is, how far back in time one establishes the baseline.

4 | DISCUSSION

Contrary to studies that suggest evidence-based conservation and management decisions are rare (e.g. see examples in Section 1, and Cvitanovic et al., 2014; Koontz & Thomas, 2018), respondents involved in wildlife management and conservation in British Columbia described relying heavily on multiple forms of knowledge to inform their decisions. However, like Lemieux et al. (2018), where knowledge use in Canada's protected areas organizations was investigated, we found local knowledge, and especially Indigenous knowledge use to be much less than western scientific knowledge, or personal and institutional experience or opinion.

Our results suggest that different types of knowledge are helpful in answering empirical and values-based management questions. For example, there is a clear indication that ILK, like western scientific knowledge, can help address purely empirical questions (e.g. How many fish in are there in this lake?). In our case, ILK is most often applied to extend and set historical baselines on wildlife and environmental change in data-poor scenarios. This confirms observations and results of other authors (e.g. Ban et al., 2018; Eckert et al., 2018; Pita et al., 2020; Reed et al., 2013). This knowledge then presumably helps wildlife managers oppose shifting baseline syndrome reducing the potential for overexploitation of nature. Clearly, questions that involve values (e.g. Should trout be introduced in this lake where they are currently and/or historically not present?) benefit from ILK. We found some evidence for management considering values such as harvest preferences and cultural importance. However, the extent to which management asks such questions to ILK holders is unclear from this data and should be an area of future work.

While respondents were generally willing and interested (and in some cases, required) to increase engagement with ILK, challenges pertaining to knowledge evaluation and use were observed. Namely, a lack of trust, hesitancy to share knowledge (particularly from Indigenous communities), difficulties in assessing reliability and difficulties discerning knowledge from advocacy, that is, 'agency capture' (i.e. undue influence on agency decision-making by special interest groups; Artelle et al., 2018).

Concerningly, regardless of knowledge type, our findings point to a diminishing role of evidence in final decisions concerning wildlife management and conservation. In other words, evidence appears to be an important consideration (as revealed by our results) but is often outweighed by other considerations, contrasting evidence-based decision-making. So, while respondents in our interviews rely heavily on multiple forms of knowledge to inform their decisions, their day-to-day decisions are generally at levels of governance that are not responsible for final decisions that concern wildlife management and conservation. In other words, the majority of participants are not at the top of the hierarchy of the organizations in which the work. We attempted to include statutory decision-makers (e.g. Deputy Ministers, Directors, and Section Heads—see 1.1 The Case) responsible for such final decisions as participants, though such people are few, as is the number of representatives of this group who participated in interviews. Hence, our results support the idea that evidence may form the basis of a decision but is often eclipsed by other, perhaps more economically or politically pressing, considerations (e.g. Artelle et al., 2018; Morrison-Saunders & Bailey, 2003). We find this in our case despite claims that decisions from statutory decision-makers in BC are grounded using an evidence-based standard (Artelle et al., 2018; Government of British Columbia, 2017). Like others have found (e.g. Lemieux et al., 2018; Nguyen et al., 2018; Young, Nguyen, et al., 2016), mobilizing knowledge in support of wildlife management and conservation is, in parliamentary governments at least, limited by a decrease in research capacity (time, staff and financial resources) and institutional knowledge integrity. A recent history of austerity at the federal and provincial levels of government is in part, likely culpable (Smith et al., 2017; Westwood et al., 2017). This may partially explain why many parliamentary government respondents attributed the heavy use of local knowledge to identifying blind spots, providing warning signs of potential crises, thus informing adaptive management.

In our case study, increased socio-economic and political interference strongly corresponded to the diminishing role of evidence

in wildlife management and conservation. It is tempting to associate the lack of evidence-based decision-making in wildlife management with the prevailing political climate. However, Artelle (2019, p. 38) suggests these 'cracks' 'run far deeper than ephemeral political cycles' and therefore should not be treated as a temporary phenomenon. Due to capacity, socio-economic and political constraints, parliamentary (and perhaps Indigenous) government natural resource managers may not be empowered to use knowledge, regardless of type, even if it is available.

As we have found here, natural resource management agencies may be perceived as reactionary regulatory bodies, increasingly distanced from the generation and use of evidence. For example, cuts to the public service in BC have resulted in much of the public interest science normally done by the province outsourced to 'qualified professionals' hired by industry and project proponents with little to no oversight (Smith et al., 2017)—putting into question the role of evidence in the public's interest. Concerning the evidence itself, it cannot be simply assumed that there is a dearth of knowledge and that generation of more knowledge, regardless of type is better, benefitting decision-makers in wildlife management and conservation. As recognized by Lemieux et al. (2018), in capacity-poor organizational settings (the case for many wildlife management agencies) information overload presents a paradox. Increases in information may further stress already limited human and financial capital as staff try to distil the relevant and credible information they need, thus overwhelming management and decision-making processes.

To overcome a lack of effective knowledge exchange, evidence synthesis (e.g. systematic reviews, systematic maps) is frequently endorsed as a logical solution to deliver relevant, accessible and timely information to encumbered environmental decision-makers (see Cook et al., 2017; Dicks et al., 2014; Pullin et al., 2016; Pullin & Knight, 2001). We recognize that evidence synthesis alone is likely not enough to improve the use of knowledge, and that more is required (e.g. knowledge brokers; Segan et al., 2011) to develop the knowledge mediation sphere (Nguyen et al., 2017). Yet, evidence synthesis is a tangible step to amplify and foster multiple forms and sources of knowledge, as well as strengthen partnerships between knowledge producers and decision-makers.

In theory, a benefit of evidence synthesis is that it can draw upon diverse knowledge sources and disciplines in a cohesive manner to comprehensively inform issues on a given matter. However, evidence synthesis has traditionally focused on knowledge from western-based, especially natural sciences (Wheeler & Root-Bernstein, 2020). This suggests that individuals and organizations that compile and review environmental evidence (e.g. The Collaboration for Environmental Evidence and Conservation Evidence, https://environmentalevidence.org; Conservation Evidence, https://www.conservationevidence.com) ought to increase efforts to include other sources of knowledge such as from Indigenous and local communities. The good news is that there are many useful ILK publications and case studies (e.g. Collier-Robinson et al., 2019; Wyllie de Echeverria & Thornton, 2019) to draw upon. This is further illustrated by the 'Bridging Indigenous and Science-Based Knowledge Initiative' under the auspices of Fisheries and Oceans Canada (DFO), a department of the Government of Canada. In the process of producing systematic evidence maps, they have found 71 studies for coastal-marine systems and 74 for freshwater in Canada alone (personal communication; Alexander et al., 2019). In practice, both western science and ILK could be synthesized and shared using a web portal containing a geospatial map, as DFO are planning. Furthermore, synthesists, like primary researchers, should move beyond consultation towards building meaningful relationships in collating and synthesizing evidence. While this will involve making calls for evidence to Indigenous and local knowledge holders, it should also involve utilizing existing Indigenous and local led knowledge platforms such as SIKU—the Indigenous Knowledge Social Network and Exchange for Local Organizations, https://siku.org and Knowledge of the Arctic (ELOKA), https://eloka-arctic.org which retain ownership, control, access and sovereignty of the data to knowledge holders.

Indigenous and local knowledge is place-based knowledge accumulated intergenerationally by close and continuous observation within specific cultural contexts, belief systems, epistemologies and worldviews (Ban et al., 2018; Díaz et al., 2015; Tengö et al., 2017). Thus, ILK is nuanced and integrates understandings of observations within the system and environmental context within which it was generated. In other words, Indigenous and local information may not, cannot and perhaps *should* not be separated from the value system and worldview which is placed. For example, in defining the quality of a fishery, Indigenous knowledge may include attributes that are also valued by western scientific knowledge (run-timing, size and abundance of a stock), as well as those that are not, such as attributes of kinship to fish (markings on fish, flavour, colour and texture) and emphasis on place of capture (Interview #22; male; Indigenous government natural resource branch affiliation). These can be considered relational values, broader than instrumental and intrinsic values, which encompass preferences, principles and elements about human relationships that involve more than just human beings (e.g. Gould et al., 2019). Hence, extracting ILK and placing it within a western-based framing as might occur in evidence synthesis risks reducing ILK systems to a collection of mere factual data and losing the full benefit of the holistic nature of these knowledge systems. ILK which generally takes a holistic approach may directly oppose western-based science and frameworks which generally takes a reductionist approach. Importantly then, standards, guidelines, and practices for ILK generation, synthesis, and weaving them with western science should be (co-)developed by ILK holders themselves, not western scientific primary researchers or synthesists. This will involve moving away from knowledge integration and knowledge co-production to a knowledge coevolution framework (Chapman & Schott, 2000). In such a framework, distinct knowledge systems are bridged and strengthened to generate new understandings while considering the normative impacts of western science and empowering local knowledge holders.

Challenges related to assessing the reliability of ILK from western decision-makers suggest a deep tension about ILK use in western frameworks. This might however be expected for non-Indigenous people given Indigenous knowledge is outside of their own knowledge

system. The prevailing perception is that ILK needs to be validated or verified by western scientific knowledge to be useful (Needham et al., 2020; Wheeler et al., 2020; Wheeler & Root-Bernstein, 2020). In addition to extracting ILK without the full involvement, collaboration, and consent of Indigenous and local knowledge holders, the desire to validate ILK furthers a lack of trust. It may also lead to the marginalization, appropriation and commodification of knowledge.

As revealed here and elsewhere (see Ainsworth et al., 2020; Ban et al., 2018; Huntington, 2000; Reed et al., 2013; Wheeler & Root-Bernstein, 2020), ILK use can yield significant benefits for environmental management. The question is no longer whether to engage ILK but how best to do this. Western decision-makers may be overly cautious in doing so, given the complicated knowledge-action space presented above. This reveals a need for training for western-based scientists and decision-makers on how to avoid bias from misunderstanding ILK and to overcome misconceptions such as the need to validate it (Wheeler et al., 2020).

Fundamentally, these results further suggest Indigenous and local peoples should be directly involved in wildlife management—using and interpreting their own knowledge as appropriate. Thus, ILK should be evaluated in reference to the knowledge system in which it is situated. Under a fair and equitable system, the salience, legitimacy and credibility of ILK would then be evaluated by knowledge holders from that knowledge system (Tengö et al., 2017; Wheeler & Root-Bernstein, 2020).

Coexistence, complementarity and alignment of western-based and ILK systems in management necessitate supporting autonomous knowledge. Practically this means, 'have them side by side so you can see the value of each, to see them for what they are'—otherwise there is a risk that 'you water each of them down' (Interview #54; female; provincial natural resources ministry affiliation). Two related concepts recently introduced in western literature may help achieve this: co-assessment of existing knowledge (Sutherland et al., 2017) and 'Two-Eyed Seeing' (Mi'kmaq principle of Etuaptmumk; Rayne et al., 2020; Reid et al., 2020). In the former, western decision-makers collaborate with ILK actors to assess the validity and relevance of external knowledge which may lead to Indigenous and locally informed knowledge synthesis and decisions. The latter brings together multiple knowledge systems side by side in which both 'eyes' view the world for the benefit of all, rather than making one 'eye' conform to the rules and assumptions of the other.

Our study population was highly biased to provincial and ENGO decision-makers. This was not intentional as we attempted to have a representative dataset covering stakeholders, Indigenous and parliamentary governments. Nonetheless, this limits our ability to infer the use of knowledge beyond primarily western decision-makers. Representatives from natural resource branches of Indigenous governments were few, as many of those contacted for requests for interviews expressed little or no interest or expertise in rainbow trout, citing identities linked primarily to salmon. So, for example, it is likely that Indigenous knowledge may indeed play a much greater role on the ground by Indigenous governments and communities, but this would not be captured by these data. Inherently, the methods employed, open-ended questions in interviews also presents limitations. The interviewer, consciously or otherwise, may influence the direction of interviewee responses through underlying personal biases or preconceptions. However, the benefits in enabling us to collect sensitive data from a wide range of practitioners and providing flexible space for interviewees to explain their positions, priorities and opinions freely and precisely was why this method was chosen over, a survey questionnaire, for example (see Young et al., 2018).

4.1 | Conclusions

Wildlife management decisions are highly meaningful, supporting the conservation of biodiversity, habitats and ecosystem services but they are extremely complex. Evidence is an important source for informing decisions under such extreme social-ecological complexity. Our results suggest that gaps between generated knowledge and knowledge users (Bertuol-Garcia et al., 2018; Toomey et al., 2017) may not be as pervasive or expansive as described in some contexts. In our case, Indigenous governments, parliamentary governments and stakeholders use multiple forms of knowledge in decision-making but rely heavily on internal (institutional) knowledge. However, despite agreement that local knowledge, and especially Indigenous knowledge, can yield significant benefits for wildlife management and conservation, it is generally under-utilized in comparison to western scientific knowledge, or personal and institutional experience or opinion. Concerningly, underlying the use of knowledge is a perception of the diminishing role of evidence in decisions concerning wildlife management and conservation. Interview respondents associated this move away from evidence-informed decision-making with decreases in institutional resources and capacity, but especially with increases in socio-economic and political interference which outweigh evidence.

This research generates further questions. We have assessed how wildlife managers evaluate knowledge, but how they procure it in organizational cultures with capacity shortages and information overload is also important. Whether potential knowledge users perceive claims as more knowledge-based or more advocacy-based and the factors which predict this outcome would benefit evidence-based management and conservation. It would be important in any follow-up work to distinguish how different types of knowledge might be more or less helpful in answering questions that mix empirical data and values (e.g. what is the sustainable level of fish harvest for this lake?), what that information would be, and how it would be used. This was a particular gap observed in this work. Furthermore, empirical investigations of co-assessing knowledge and applying the 'Two-Eyed Seeing' approach are needed to assess their effectiveness and limitations in wildlife management contexts (Reid et al., 2020; Sutherland et al., 2017).

For wildlife management to be truly adaptive and effective, drawing on the full complement of evidence to develop a holistic and collective understanding of the natural world seems desirable. Thus, more is needed to improve the use of evidence. Particularly, we emphasize the need for knowledge brokers; standards,

guidelines and practices for ILK generation and synthesis developed by knowledge holders; and collaborations and partnerships between and within western science, Indigenous and local communities which embrace knowledge coevolution (Chapman & Schott, 2000). We encourage transformative changes in wildlife management towards direct involvement of knowledge holders, co-assessment of knowledge and transparency in how (multiple forms of) evidence contribute to decision-making. These changes also pertain to organizational cultures so that wildlife managers are motivated and enabled to apply multiple forms of knowing to advance decisions that yield co-beneficial management and conservation outcomes for both people and nature. We believe this can help overcome a lack of trust, hesitancy to share knowledge, difficulties in assessing reliability and difficulties discerning knowledge from advocacy.

ACKNOWLEDGEMENTS

This research was supported by Genome British Columbia/Genome Canada [242RTE]. A.N.K. was further supported by the Natural Sciences and Engineering Research Council of Canada (NSERC) [PGSD2-534299-2019]. S.J.C. was further supported by NSERC and the Canada Research Chairs program. We graciously thank Elise Urness, Carmen Gudino and Danny Glassman who provided support in transcribing data. We thank the Editor, Associate Editor and two anonymous reviewers whose comments on previous versions of this manuscript greatly improved this article.

CONFLICT OF INTEREST

We declare that we have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

AUTHORS' CONTRIBUTIONS

A.N.K., S.J.C. and N.Y. conceived the ideas and designed the methodology; A.N.K. collected and analysed the data; A.N.K. led the writing of the manuscript. All authors contributed critically to the drafts and gave final approval for publication.

DATA AVAILABILITY STATEMENT

There are no linked research datasets for this submission because the data that have been used were collected from human participants in confidentiality and anonymity under our certificate of ethics approval: University of Ottawa Research Ethics Board (File Number: 02-18-08). Archiving the data openly may compromise the confidentiality and anonymity of human participants. However, raw counts and references made by respondent groups are openly available in Appendix A and the thematic codebook in the Supporting Information.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

How to cite this article: Kadykalo AN, Cooke SJ, Young N. The role of western-based scientific, Indigenous and local knowledge in wildlife management and conservation. *People Nat*. 2021;3:610–626. https://doi.org/10.1002/pan3.10194