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RESEARCH ARTICLE

Evidence-based decision-making in Canada's protected areas organizations: Implications for management effectiveness

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Abstract

Aichi Biodiversity Target 19 calls on Parties to the United Nations Convention on Biological Diversity (CBD) to improve, share, transfer, and apply knowledge. In this study, we provide an initial assessment of the state of evidence-based decision-making in Canada's protected areas organizations by examining (1) the value and use of various forms of evidence by managers and (2) the extent to which institutional conditions enable or inhibit the use of evidence in decision-making. Results revealed that although managers value and use many forms of evidence in their decision-making, information produced by staff and their organizations are given priority. Other forms of evidence, such as Indigenous knowledge and peer-reviewed information, are valued and used less. The most significant barriers to evidence-based decision-making were limited financial resources, lack of staff, inadequate timeframes for decision-making, a lack of monitoring programs, and a disconnect between researchers and decision-makers. Overall, our results suggest that the potential benefits of evidence-based approaches are not being maximized in Canada's protected areas organizations. We propose several recommendations to introduce or improve the use of diverse forms of evidence to enhance management effectiveness of Canada's protected areas and by extension conservation outcomes.

Key words: protected areas, conservation, evidence, decision-making, management effectiveness, biodiversity

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Introduction

Protected areas are a cornerstone of biodiversity conservation and are acknowledged as a key tool for the protection of biodiversity under Article 8 of the United Nations Convention on Biological Diversity (CBD) (United Nations 1992; Secretariat of the Convention on Biological Diversity 2014a). In 2010, parties to the CBD responded to growing concerns over biodiversity loss by adopting an updated Strategic Plan for Biodiversity, including 20 "Aichi Biodiversity Targets" for the 2011–2020 period (decision X/2) (UNEP 2010). Aichi Biodiversity Target 11 (UNEP 2010) calls on parties to ensure that 17% of terrestrial area and 10% of marine area "are conserved through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscape and

seascape". Aichi Biodiversity Target 11 (UNEP 2010) attempts to shift management practice beyond simply measuring the number and extent of protected areas to measuring success in terms of achieved biodiversity conservation outcomes. This shift means that management "effectiveness", or the extent to which management is protecting values and achieving goals and objectives (Hockings 2006), will be a critical criterion for assessing progress on conservation goals under the CBD (e.g., Secretariat of the Convention on Biological Diversity 2014b).

The expansion of protected areas called for under Aichi Biodiversity Target 11 (UNEP 2010) will create a suite of complex implementation challenges for policy-makers, planners, and managers. In this paper, we argue that a sound evidence base is needed to enable Canada's protected areas community to select the most appropriate collective actions to implement this target. Evidence shows that appropriately located and managed protected areas can help reduce the risk of species' extinctions and can reverse negative population trends (Secretariat of the Convention on Biological Diversity 2014a; UNEP-WCMC and IUCN 2016). Establishing an "ecologically representative" and "well-connected" network of protected areas will place comprehensive informational demands on organizations and decision makers (see Di Minin and Toivonen 2015), necessitating collaboration between conservation organizations and other land/marine stewardship groups (e.g., private organizations, Indigenous peoples) operating at adjacent and (or) different administrative levels.

A stronger focus on the management effectiveness of protected areas is key to meeting Aichi Biodiversity Target 11 (UNEP 2010). As Legge (2015, pp. 113–114) aptly stated, "... while our investment in conservation is growing, and our efforts to measure and report on conservation 'activity' are increasing, our ability to report the ecological outcomes is not". More and better quality information to support sound management actions and related conservation outcomes is necessary (see Geldmann et al. 2015). Comprehensive decision support is required throughout the ongoing planning and management cycle of collecting and analyzing information, decision-making, monitoring, and evaluating to effectively conserve biodiversity. This may include one or more of the following:

1. generic management approaches where specific areas are managed in accordance with common legislative and policy directives;
2. management plan development including data collection, analyses, plan formulation, and consultation leading to the completion of a formally approved management plan;
3. management plan implementation including the execution of management actions prescribed in a formally approved management plan;
4. specific/subordinate plans dealing with management issues/needs such as restoration, species reintroduction, fire management, invasive species, climate change, etc.; and
5. formal plan reviews conducted periodically to assess and refine approved plans as necessary to accommodate changing needs, new information and/or knowledge, and new management techniques.

Most Parties to the CBD currently report that an absence or difficulty in accessing scientific information is a major obstacle to the implementation of the goals of the CBD (Secretariat of the Convention on Biological Diversity 2018). The need for more and better information to support decision-making is also recognized in Aichi Biodiversity Target 19 (UNEP 2010), which states that "[b]y 2020, knowledge, the science base and technologies relating to biodiversity, its values, functioning, status and trends, and the consequences of its loss, are improved, widely shared and transferred, and applied". At the scale of most protected areas, it has been found that the information required to assess management effectiveness is currently missing (Di Minin and Toivonen 2015).

Although no national assessment of management effectiveness has been conducted for Canada's protected areas sector, independent audits by government and assessments by science-based non-governmental organizations (NGOs) have observed that ministries responsible for species at risk and protected areas have not been able to meet their legislated goals and responsibilities (e.g., British Columbia Office of the Auditor General 2010; Office of the Environmental Commissioner of Ontario 2013; Canadian Parks and Wilderness Society 2016). This includes a report from the Office of the Auditor General of Canada (2013) that concluded Parks Canada has struggled in its efforts to maintain or restore ecological integrity in national parks due to a lack of information for decision-making (e.g., monitoring data), decreased spending, and significant declines in staffing (including a decline in scientific staff by one-third).

The goal of this paper was to provide an initial assessment of the state of evidence-based decision-making in Canada's protected areas organizations. We used a survey that assessed (1) the value and use of different forms of evidence among protected areas managers and (2) the extent to which institutional features (such as human resources, information management systems, and partnerships) enable or challenge the integration of evidence into decision-making. We proceeded on the implicit assumption that better access and use of various forms of evidence for decision-making is fundamental to management effectiveness, and that the need for evidence-based decision-making will become even more important as the global conservation community transitions from an emphasis on establishing protected areas to a focus on effectively managing the protected areas estate. We provide recommendations to enhance evidence-based practice in protected areas management.

Research context

Study system

Canada has 7 864 protected areas across its provinces and territories that encompass approximately 10.57% of Canada's total terrestrial area and 0.98% of its marine area (Canadian Council on Ecological Areas 2016). Since ratifying the CBD in 1992, the protected areas estate in Canada has doubled in size. Despite the fact that Canada's network of terrestrial protected areas is the fourth largest in the world (105 264 282 ha), organizations in Canada are just beginning to consider management effectiveness and its evaluation (Canadian Council on Ecological Areas 2016; Environment and Climate Change Canada 2016). Achieving protection of 17% and 10% of the terrestrial and marine area, respectively, by 2020 is regarded as a challenging goal given the current area under protection, financial constraints, political support, and issues surrounding protection standards and ability to manage the protected areas estate effectively (MacKinnon et al. 2015).

Management effectiveness and evidence-based decision-making

Several frameworks exist for evaluating management effectiveness in both terrestrial and marine protected areas (Pomeroy et al. 2004; Chape et al. 2005; Hockings 2006). While assessment criteria vary across frameworks, they generally reflect three main themes in protected areas planning and management:

1. design issues (relevant to individual sites and protected areas systems),
2. adequacy and appropriateness of management systems and processes, and
3. delivery of protected areas outcomes and objectives including the conservation of targeted values.

In response to increasing concerns about the capacity and effectiveness of management for protected areas in Canada (e.g., Office of the Auditor General of Canada 2013; Canadian Parks and Wilderness Society 2016), the present study focuses on this aspect rather than design issues associated with systems planning for protected areas and area networks.

Global assessments of protected areas management effectiveness have revealed major deficiencies across many criteria, including funding, human capital, and capacity to assess management effectiveness itself (Geldmann et al. 2015). Arguably, the lack of capacity to assess management effectiveness is a foundational barrier, as appropriate actions to address other deficiencies must stem from a clear understanding of existing institutional baselines. The international conservation community has therefore called for greater measurement, evaluation and communication of conservation effectiveness (e.g., United Nations CBD Programme on Protected Areas, Goal 4.2 (UNEP 2018)).

Given that acknowledged deficiencies in the planning and management of biodiversity conservation and recovery include gaps in both data (e.g., range, occupancy, time-series data, extinction risk of species, see Buckley et al. 2008; Federal, Provincial, and Territorial Governments of Canada 2010; Mooers et al. 2010; Cvitanovic et al. 2015) and capacity to mobilize data, management effectiveness seems closely coupled to evidence-based decision-making. Adams and Sandbrook (2013) emphasize that evidence for conservation should consider a broad range of evidence types, including qualitative data and Indigenous knowledge. Bennett (2016, p. 1) likewise defines evidence as "any information that can be used to conclude and support a judgment . . . to make decisions that will improve conservation policies, actions, and outcomes". Although effective conservation management fundamentally requires a strong evidence base that includes multiple forms of evidence, a small body of research shows that managers rarely use research-based evidence to inform their decisions (e.g., Cook et al. 2012). Instead, managers often default to experience or anecdotal evidence when making important decisions (Ausden et al. 2001; Pullin and Knight 2005; Cook et al. 2010; Cook and Hockings 2011; Giehl et al. 2017).

The choice of what evidence to access and deploy in a management decision involves individual judgment, but it is also influenced by the values, norms, and shared meanings that make up an organization's culture (Bass and Avolio 1993; Büschgens et al. 2013). While rules, structures, and procedures for decision-making shape the use of evidence within conservation organizations (Keene and Pullin 2011), organizational culture refers to the "mental phenomena" that shape the way a group thinks about and values reality (Alvesson and Sveningsson 2008). Pullin and Knight (2005, p. 1995) reflected on the organizational culture of conservation practice and identified several dimensions that present a challenge to greater evidence utilization, including a "suspicion of the value and motives of researchers". Importantly, case studies of management in protected areas have also shown that organizational culture can influence aspects of conservation practice at the level of individual decision-makers. For instance, Larsen and Valentine (2007) found that staff responsible for managing tourism and recreation functions in North Queensland's protected areas were more likely to believe that tourism was an asset (in addition to ecosystem protection) if they had previously worked in organizations where a multiple-use resource management philosophy predominated.

Whether and how evidence is deployed in conservation management will be key to achieving the "effective management" dimensions of Aichi Biodiversity Target 11 (UNEP 2010). Research has shown that well-summarized scientific evidence can direct management choices away from ineffective interventions when it is timely and packaged in a format that meets the needs of practitioners (Walsh et al. 2015). Aichi Biodiversity Target 19 (UNEP 2010), which has received virtually no attention compared with the other 19 targets, outlines a key path to enhancing management effectiveness as it calls on parties to improve, transfer, share, and apply knowledge. Clearly

understanding and demonstrating how evidence contributes to desired conservation outcomes, however, can be a complex and difficult task for managers, particularly when they lack access to external, independent assessments of management effectiveness (Sutherland et al. 2004; Pullin and Knight 2005; Arlettaz et al. 2010; Cook et al. 2010; Cook and Hockings 2011; Segan et al. 2011; Cvitanovic et al. 2016).

Methods

Our research methodology paired a literature review on evidence-based decision-making with a national survey of Canadian protected areas managers. Following Bennett (2016) and Adams and Sandbrook (2013), our survey considered evidence and its application in decision-making broadly by assessing multiple forms of evidence in policy-making, management planning, active management, education and outreach, and other efforts to enhance protected areas management effectiveness (see Introduction). We reviewed more than 30 publications (including journal articles, books, and organizational documents) covering biodiversity conservation, protected areas management, and management effectiveness evaluation[1]. Although our review was extensive, our primary aim was not to be exhaustive. Rather, we sought to develop a representative framework describing evidence-based decision-making that would inform our survey and recommendations.

There is little clarity in the protected areas community about the different factors that affect evidence-based decision-making, and no formal, standardized evaluation mechanisms exist. Our review revealed that evaluations of the value and use of evidence in decision-making vary by context and stakeholder interests as well as the stated purpose of the research (e.g., climate change, threatened species, and spatial planning). Evaluation objectives in the literature that we reviewed ranged from broad information use (basic research application) to directly informing accountability, transparency, program improvement, status/impact assessment, and resource allocation. To address this complexity, we analyzed the literature to identify the different conditions (or factors) that influence evidence-based decision-making. We identified 18 conditions (or factors) and organized them under the broad themes of "regulatory and operational", "informational", "human resource capacity", "contextual", and "cultural and behavioural" (**Table 1**, see also **Supplementary Material 1**).

Using these factors and other results from the literature review we developed an online survey tool to measure managers' perceptions of evidence-based decision-making within their agency. We targeted managers who are responsible for decisions about protected areas management, including day-to-day decisions at a local level (e.g., protected areas specific management activities) and long-term, strategic decisions (e.g., guiding policy, resource allocation for management activities). Perceptions refers "to the way an individual observes, understands, interprets, and evaluates a referent object, action, experience, individual, policy, or outcome" (Bennett 2016, p. 4).

The survey was pretested with four managers who coordinate monitoring and evaluation activities for several different conservation organizations. Ethical approval was provided by the Trent Research Ethics Board to the project, "Biodiversity science and conservation in southern Ontario: historical, contemporary, and spatial dimensions," (REB #21713) which included this survey. A key objective for the distribution of our survey was to ensure responses from organizations whose management responsibilities cover protected areas across Canada. Our sample covered all governmental protected areas in Canada, as well as several NGOs. We did not anticipate that an understanding of evidence use would be equally distributed among staff within these organizations. Accordingly, we worked with the

[1]In addition to references included with the main body of the article, see **Supplementary Material 1**.

Table 1. Factors affecting the access and use of empirical evidence in decisions pertaining to protected areas management.

Factor	Description	Source
Regulatory and operational	Lack of policy that prioritizes and (or) promotes the use of evidence-based information (e.g., not empowered to use information, lack of reward system for use)	Sutherland et al. (2004); Sheikheldin et al. (2010); Cvitanovic et al. (2016)
	Financial constraints, including costs of collecting empirical information (e.g., research and monitoring programs)	Grantham et al. (2008, 2009); Bottrill et al. (2009); Arlettaz et al. (2010); McDonald-Madden et al. (2010); Sheikheldin et al. (2010); Waithaka (2010); Cvitanovic et al. (2016)
Informational	Lack of available credible empirical information	Arlettaz et al. (2010); Cook et al. (2010); Sheikheldin et al. (2010); Chandra and Idrisova (2011)
	Access to empirical information (limited access or difficult to access)	Sutherland et al. (2004); Fazey et al. (2005); Pullin and Knight (2005); Ferraro and Pattanayak (2006); Roux et al. (2006); Arlettaz et al. (2010); Gibbons et al. (2011); Cvitanovic et al. (2016); Giehl et al. (2017)
	Lack of trust (credibility, legitimacy, transparency) associated with empirical information (e.g., transparency in methods)	Roux et al. (2006)
	Lack of relevance or applicability to unique policy or management planning contexts (e.g., salience)	Fazey et al. (2005); Balmford and Cowling (2006); Haseltine (2006); McNie (2007); Knight et al. (2008); Arlettaz et al. (2010); Hickey et al. (2013); Dicks et al. (2014); Cvitanovic et al. (2016)
	Uncertainty associated with results	Watson (2005); Sheikheldin et al. (2010); Dicks et al. (2014)
	Management prescriptions are not quantitatively explicit (e.g., cost effectiveness of management options are not evaluation, differential cost of action vs. inaction)	Prendergast et al. (1999); Watson (2005); Arlettaz et al. (2010)
	Conflicting scientific results	Burkardt and Ruell (2012)
Capacity	Lack of time (e.g., too time consuming to locate, access, and read)	Pullin and Knight (2005); Waithaka (2010)
	Limited training or experience in critically evaluating information (language barriers, technical nature of research, foreign languages, scientific jargon)	Pullin and Knight (2005); Watson (2005); Roux et al. (2006); Holmes and Clark (2008); Arlettaz et al. (2010); Hickey et al. (2013); Cvitanovic et al. (2016); Giehl et al. (2017)
	Lack of adequate staff (e.g., lack of in-house/embedded science expert in agency and other science support staff)	Holmes and Clark (2008); Lemieux et al. (2011, 2015)
Contextual	Management prescriptions are not spatially explicit (inadequate spatial scale for decision making)	Prendergast et al. (1999); Watson (2005); Roux et al. (2006); Arlettaz et al. (2010); Danielsen et al. (2010); Cvitanovic et al. (2016)
	Management prescriptions do not consider unique decision making contexts (e.g., lack of political support, integrated decision-making processes)	Prendergast et al. (1999); Roux et al. (2006); Lawton (2007); Arlettaz et al. (2010); Dicks et al. (2014)
	Temporal mismatches between research and policy/management needs (including time lags between required knowledge and management planning information needs, preference for "quick fixes" to deal with problems)	Kareiva et al. (2002); Watson (2005); Roux et al. (2006); Gibbons et al. (2008); Danielsen et al. (2010); Waithaka (2010); Young and Van Aarde (2011); Cvitanovic et al. (2016)
Cultural & Behavioural	Inadequate internal knowledge transfer mechanisms (lack of iteration and interaction with knowledge producers, reliance on others to feed information)	Lemos and Morehouse (2005); Pullin and Knight (2005); Roux et al. (2006); Sheikheldin et al. (2010); Dicks et al. (2014); Keeler et al. (2017)
	Inadequate external knowledge transfer mechanisms (e.g., knowledge brokers, boundary organizations, knowledge networks) to mediate between knowledge producers and knowledge users	Cook et al. (2013); Cvitanovic et al. (2013, 2016); Dicks et al. (2014)
	Disconnect/mismatch between research agendas, knowledge user needs, and policy processes (needs not effectively communicated, science incapable of contributing to the value-based context that usually governs real-world problem solving)	Roux et al. (2006); Klenk and Hickey (2011); Dicks et al. (2014); Cvitanovic et al. (2016)

Canadian Council on Ecological Areas (CCEA)[2] Directors and Jurisdictional Representatives to identify personnel who could best speak to the status of evidence-based practice within organizations across Canada. Using this purposive sampling strategy within each organization allowed us to identify the "unique cases" that would provide the most relevant information about an organization and to avoid collecting data from a random, but potentially uninformed, sample (Teddlie and Yu 2007). Given the sampling strategy used to identify participants within organizations, our results provide an informed assessment of the status of evidence-based decision-making in Canada's protected areas organizations, but may not be representative of all managers in Canada.

Given the clear advantages of a web-based survey to the research team (e.g., broad geographic coverage and limited costs, faster distribution and response time, ease of data collection) and to participants (e.g., ample time to consider responses unimpeded by the presence of an interviewer or limited space often provided in paper copies), an online protocol (SurveyMonkey) was the sole mode of survey distribution and response, even though the options of PDF and paper copies of the survey were offered to participants. The survey was forwarded to CCEA Jurisdictional Representatives and other relevant senior staff within NGOs (e.g., directors, managers, and coordinators) who forwarded the survey onto appropriate personnel. Participation was voluntary, and participants were made aware that they would not be identified by name (and that their responses would remain confidential to other participants). When responding to questions, we asked participants to think in terms of their recent experiences within their organization (i.e., up to the past 5 years). Finally, participants were informed of the knowledge transfer activities associated with the research, including publications and presentations reporting the results of the research.

The final survey included both closed-ended and open-ended questions. First, participants indicated the extent to which they value and generally use different forms of evidence on four-point Likert scales ranging from "not valuable at all" to "very valuable" and from "never used" to "always used". Participants also evaluated the extent to which they agreed with statements about potential barriers to evidence-based decision-making in their organization using a 5-point Likert scale ranging from "strongly disagree" to "strongly agree". Participants were provided a description indicating that "evidence" might include quantitative or qualitative ecological or social data as well as local knowledge and Indigenous knowledge. Participants were also given a description of each form of evidence they evaluated. For instance, peer-reviewed scientific research was described as "information derived from published studies found in peer-reviewed journals". Several questions on participant employment experience, gender, and training were also included.

Finally, as suggested by Dillman (2007), a statement of endorsement for the study by the CCEA was included to encourage participation and to acknowledge the value of the study. The survey was sent to 175 potential respondents and was completed by 121 participants. Responses amenable to quantitative analysis were analyzed in SPSS version 23 (IBM, Armonk, New York) using factor analysis, and basic inferential and descriptive statistics.

Results

The response rate for the survey was 69.1% (n = 121), which is notably higher than other studies of conservation managers, where time constraints have often limited participation (e.g., Cook et al. 2012).

[2]The CCEA was incorporated in 1982 as a national, non-profit organization with a mission "to facilitate and assist Canadians with the establishment and management of a comprehensive network of protected areas representative of Canada's terrestrial and aquatic ecological natural diversity". The CCEA is composed of experts from all federal, provincial, and territorial governments, as well as academic and NGO communities, and is a member of the International Union for the Conservation of Nature (IUCN). Board members and jurisdictional representatives of the CCEA assisted with the identification of suitable respondents. See CCEA.org for more information.

In addition to participants representing government agencies, several managers from "special purpose" NGOs and land trust programs with science-based management planning mandates participated (Table 2). To identify any potential non-response bias, we used paired sample *t* tests to compare the distribution of respondents and non-respondents according to the types of protected areas managed and found no significant differences.

The gender split of our sample included a slightly higher proportion of males (55%) and, on average, respondents were highly educated (>50% with a graduate degree), had been involved in protected areas management for 11 years, and had been employed by their current organization for 13 years (minimum = 1; maximum = 38). Most had an educational background in natural sciences (65%), with lower representation from the social sciences (<12%) and other relevant fields including business and economics (<6%) and humanities (<3.9%) (Table 3). Current involvement in protected areas management was well dispersed in all program areas, including legislation, strategic planning, selection and design, management, research and monitoring, and education and outreach.

Value and use of evidence

Participants generally took the position that many forms of evidence are relevant to their protected areas management efforts (Table 4), while noting that evidence produced by both their staff and their

Table 2. Summary of survey respondents by organization.

Organization	*n*
Federal government	
Parks Canada Agency	8
Environment Canada	2
Department of Fisheries and Oceans	8
Provincial/territorial government	
Alberta	33
British Columbia	8
Newfoundland	1
Nunavut	1
Prince Edward Island	1
Saskatchewan	2
Manitoba	2
Northwest Territories	2
Nunavut	4
Ontario	26
Quebec	6
Yukon	4
Private	
Nature Conservancy of Canada	10
Ducks Unlimited	3
Total	**121**

Table 3. Demographics of the survey respondents.

	Gender split (*n*)			Education level (*n*)					Experience in protected areas (y)	
Organization type	Female	Male	Data missing	Below Bachelor's	Bachelor's	Master's	PhD	Data missing	Median	Range
Federal	7	10	1	0	4	9	5	0	13	1–30
Provincia/Territorial	35	49	6	12	32	34	7	5	12	1–38
Private	6	7	0	0	3	6	4	0	12	2–30

Table 4. Value and use of various forms of evidence in Canada's protected areas agencies.

Form of evidence	Value mean[a]	SD	Use mean[b]	SD
Legislation	3.5	0.7	3.4	0.8
Staff assessments	3.8	0.4	3.3	0.7
Policy	3.3	0.7	3.2	0.8
Thematic mapping	3.5	0.7	3.2	0.8
Institutional knowledge	3.4	0.7	3.1	0.7
General management plans	3.1	0.8	2.9	0.9
Specific management plans	3.1	0.8	2.7	0.8
Database	3.0	0.9	2.7	0.9
Strategic plans	3.0	0.8	2.7	0.8
Local knowledge	3.2	0.8	2.6	0.8
Consultant reports	3.1	0.8	2.6	0.7
Expert consultant reports	3.2	0.7	2.6	0.8
Peer review	3.0	0.8	2.5	0.7
Grey literature	2.7	0.7	2.4	0.7
Traditional knowledge	2.9	0.9	2.2	0.9
International agreements	2.6	0.8	2.1	0.7

[a]Value scale: 1 = Not at all Valuable; 2 = Moderately Valuable; 3 = Valuable; 4 = Very Valuable.
[b]Use scale: 1 = Never Used; 2 = Occasionally Used; 3 = Frequently Used; 4 = Always Used.

organizations were more valuable than other forms of evidence (such as peer-reviewed literature). For example, over 98% of participants indicated that they perceived evidence produced by staff as "valuable" or "very valuable", whereas far fewer participants rated evidence derived from international agreements (such as the CBD and the technical works of its Secretariat) or grey literature as "valuable" or "very valuable" (52% and 57%, respectively). A much larger proportion (88%) of respondents also rated evidence drawn from institutional knowledge as "valuable "or "very valuable" compared with evidence drawn from other forms of knowledge, including Indigenous knowledge (68%).

Participants also reported that evidence obtained directly from their respective work environment was used most frequently in decision-making. Evidence most often reported as "always used" or

"frequently used" was drawn from staff assessments (90%), policy and legislation[3] (82%), and institutional knowledge (81%). By far, evidence drawn from international agreements and Indigenous knowledge were identified as the least used, with "never used" or "occasionally used" reported in management decisions 80% and 71% of the time, respectively.

Results based on descriptive statistics can be summarized as follows:

- Managers value all forms of evidence more than they use it, in all cases.
- Managers both value and use evidence developed within their own working context the most (e.g., staff assessments, institutional knowledge).
- Managers both value and use evidence from peer-reviewed research, Indigenous knowledge, grey literature, and international agreements the least.
- Managers value Indigenous knowledge more than they use it in decisions pertaining to protected areas management, and the use of Indigenous knowledge is relatively low overall.

Tests of significance with respect to the value and use of various forms of evidence revealed additional insights. First, there were significant differences between men and women with regard to the value of Indigenous knowledge ($t = 4.282$, $p < 0.05$) and international agreements ($t = 2.235$, $p < 0.05$), suggesting that women value these forms of evidence more than men. Second, significant differences in the value of peer review ($t = 2.900$, $p < 0.05$) and grey literature ($t = 2.483$, $p < 0.05$) were evident based on level of education and suggest that the perceived value of these forms of evidence is higher for those with graduate degrees. Finally, bivariate analysis revealed that work experience (i.e., years spent in a protected area career) ($r = -0.213$, $p < 0.05$) was negatively correlated with perceived value of Indigenous knowledge, although the correlation was weak.

Principal component analysis was used to explore further the value and use of various forms of evidence by managers (**Supplementary Material 2**). Principal component analysis is a multivariate statistical technique that represents the "important information" from a series of inter-correlated variables in new variables that are referred to as principal components (Abdi and Williams 2010). Unlike factor analysis, in which measured variables are related to an unobserved common latent factor, principal components are linear combinations of measured variables that retain maximum information from the original measured items (Fabrigar et al. 1999).

When loadings <0.30 were excluded, the analysis yielded a 12-factor solution with a simple structure. We report on the first three factors (or clusters), which comprised 35% of the total variance. Twenty-seven items loaded onto factor 1 (16.2% of total variance). It is clear from this factor that participants value and use most forms of evidence in their work, except for peer review and grey literature. Items that loaded on factor 2 were in strong contrast to those comprising factor 1 (factor 2 explained 10.2% of total variance, 15 items loading). This group of participants was highly educated, valued and used peer review and grey literature, and tended not to use organizational evidence such as management plans, legislation, and other forms of institutional knowledge in decision-making. The third factor included eight items representing 8.2% of the total variance. This group was comprised of older males with many years of management experience that use staff assessments to inform decision-making and value and use Indigenous knowledge much less. They also value local knowledge less than other forms of evidence.

[3]In Canada, legislation and policy in many cases have an evidence basis and set the evidentiary bar for planning and management standards and practices, such as size standards for wilderness designations, targets for ecological representation, ecological integrity measures, etc.

Barriers to evidence-based decision-making

In addition to analyzing the use and valuation of different forms of evidence, we assessed perceived barriers to evidence-based decision-making (Table 5). The largest barriers affecting evidence-based decision-making by managers were reported as limited financial resources (79% "moderately agree" or "strongly agree"), lack of staff (71%), inadequate timeframes for decision-making (73%), lack of monitoring programs (70%), and disconnect between researchers and decision-makers (65%). Conversely, most managers trust, but do not necessarily utilize or value, a variety of different forms of evidence, with over 85% identifying trust as an insignificant barrier (or taking a neutral position on this factor). Most managers also perceived that they are adequately trained to interpret evidence, and that uncertainty in results is not a significant barrier to decision-making. These findings were consistent across organizations. Key perceived barriers to evidence-based decision-making were largely independent of demographic and career characteristics, suggesting some consistency of experience and opinion across Canada's protected areas organizations.

A bivariate analysis of key perceived barriers to evidence-based decision-making revealed that with one exception, there were no significant correlations between barriers and demographics like age, education, and time spent in a protected areas career. The lack of monitoring programs was negatively

Table 5. Perceived barriers that affect the access and use evidence in protected area management and planning.

Barrier[a]	Mean	SD
Limited financial resources	4.1	1.0
Lack of staff	3.9	1.1
Lack of time	3.9	1.1
Inadequate timeframes for decision-making	3.8	0.8
Lack of monitoring programs	3.8	1.2
Disconnect between researchers and decision-makers	3.8	1.1
Lack of decision-making context	3.6	1.0
Lack of scale	3.6	0.9
Not quantitatively explicit	3.6	0.9
Inadequate internal knowledge transfer	3.5	1.0
Inadequate external knowledge transfer	3.4	0.9
Lack of directional policy	3.2	1.2
Relevance of information	3.2	1.1
Access to information	3.1	1.2
Availability of information	3.0	1.1
Lack of training	3.0	1.1
Uncertainty of results	3.0	0.9
Conflicting results	2.9	1.0
Lack of trust in information	2.4	1.0

[a]Barrier scale: 1 = Strongly Disagree; 2 = Moderately Disagree; 3 = Neutral; 4 = Moderately Agree; 5 = Strongly Agree.

correlated with level of education ($r = -0.199$, $p < 0.05$), but only weakly. Therefore, it appears that those "higher on the curve" may be more inclined to develop or support monitoring programs than those less versed in scientific approaches. As a whole, key perceived barriers to evidence-based decision-making were largely independent of demographic and career characteristics, suggesting consistency of experience and opinion across Canada's protected areas organizations.

Discussion

Like other studies conducted in different political and socio-economic contexts (see Pullin and Knight 2005; Cook et al. 2010; Giehl et al. 2017), Canadian protected areas managers rely primarily on evidence developed within their organization to make management decisions. Managers rely heavily on internal staff assessments and institutional knowledge, and use other sources of information like Indigenous knowledge and (or) peer-reviewed research less frequently. This pattern reveals a clear tendency in what managers value and use in their decision-making. Reasons for this are difficult to discern with certainty, and additional qualitative research is needed to explore the "why" aspects of many of these findings. However, our results indicate a skeptical or unreceptive perception of Indigenous knowledge among managers, as it is both valued and used much less than other forms of evidence. This presents a potentially concerning disconnect in the management of protected areas, which increasingly involve co-management with local Indigenous peoples. As Tipa and Welch (2006, p. 389) argue, Western management and knowledge utilization approaches have generally failed to yield sustainable outcomes regarding resource management. As such, whether in the context of co-management or not, "Indigenous environmental knowledges, predicated on sustainability principles, would appear to be especially valuable resources in their own right. The issue for governments therefore is not so much whether to engage Indigenous knowledge but how best to go about this".

Beyond the value and use of forms of evidence, our findings point to a more general pattern of decision-making that is deeply entrenched in the settings that Canadian protected areas managers work in, especially in the case of experienced managers. This is not to say that there is not an important role for individual experience and expertise in interpreting information for decision-making. However, as Dicks et al. (2014, p. 611) state, the personal experience of a decision-maker, often essential for effective action, can also lead "... to the propagation or entrenchment of poor or untested practice, a risk that is reduced if the sources of evidence and experience used to inform decisions are transparently recorded".

To make a real difference for biodiversity conservation, efforts to produce multiple forms of evidence, including Indigenous knowledge and peer-reviewed research, must be paired with efforts to understand how staff procure evidence, apply it, and monitor outcomes effectively within the context of their organizational culture. The wide variation in the valuation and use of various forms of evidence revealed in our results, as reflected in the diverging appetites for evidence among the three respondent clusters identified in our study (**Supplementary Material 2**), suggests that notwithstanding financial constraints, managers currently have a lot of latitude in selecting and applying information. This suggests that there may be little shared sense of the value for utilizing diverse forms of evidence in decision-making and no norm across the protected areas sector that dictates best practices for the procurement and application of research and information to ensure a "culture of excellence" in management effectiveness.

Although we did not directly assess scientific literacy among managers, our results suggest that there may be a level of comfort among a specific cohort of highly educated practitioners in managing the challenge of procuring and utilizing a diverse evidence base in decision-making. The second cluster of respondents demonstrated a deeper appreciation for the use of multiple forms of evidence to

support decision-making, including peer-reviewed scientific research (**Supplementary Material 2**). While this finding contrasts with the results of other studies conducted in the conservation domain (e.g., Cook et al. 2010 who found that managers use mostly past experience and personal opinion rather than scientific literature), it should be recognized that practitioners who know how to access and deploy information in a timely manner will be better positioned to deal with uncertain management issues like climate change (see Lemieux et al. 2011). Encouraging this potential organizational sub-culture may prove important to increasing the use of planning and management tools (e.g., scenario planning) that can help agencies address uncertainty by setting goals that improve the effectiveness of conservation decision-making and outcomes across a range of possible futures.

Beyond agency ranks, perhaps more effort is also needed to facilitate collaboration between the research community and the protected areas fraternity. At a national level, the CCEA facilitates collaboration between researchers and protected areas practitioners, and counterparts to the CCEA support a similar function at a provincial scale (e.g., the Centre for Applied Science in Ontario's Protected Areas (CASIOPA, casiopa.mediamouse.ca), the Parks and Protected Areas Research Forum of Manitoba (PPARFM, pparfm.org/index.html), and the BC Protected Areas Research Forum (BCPARF, unbc.ca/bc-protected-area-research-forum). These forums stage conferences, workshops, and other initiatives that link researchers and conservation practitioners, and offer an established space where collaborative efforts to improve the generation, procurement, and utilization of scientific research for protected areas and associated conservation efforts can be enhanced.

It seems clear from the survey results that Canadian protected areas managers face a suite of complex barriers in the use of evidence-based information. Even if evidence appropriate to their scale of management is available and accessible, it does not seem that all managers perceive themselves to be empowered to use information due to a lack of time, staff, and financial resources. The finding that managers do not perceive access to evidence as a key barrier is contrary to other studies (e.g., Matzek et al. 2014), and we argue that a recent history of austerity at the federal and many provincial levels of government in Canada has resulted in a shortage of capacity to mobilize evidence in support of effective management (see Introduction).

In the context of effective protected areas management, these findings suggest that it cannot simply be assumed that more evidence is always a benefit to managers. Increased availability and access to evidence may be beneficial in capacity-rich organizational settings, where there are resources to interpret and act on new information. However, in capacity-poor settings evidence overload may overwhelm the management process, and paradoxically, further stress already limited human and financial capital as staff sift and sort to find evidence that is relevant to their purpose and regional context. While our results support the finding that managers increasingly look inward to their institutions for evidence the longer they are with an institution, there is a possibility that this pattern is part of a coping mechanism that allows managers to deal with information overload in times of capacity constraints. Exploring how managers cope with information overload in capacity poor settings seems an important area for future research.

Beyond future research, we argue that new avenues must be sought to help shift the dialogue about management effectiveness toward coordinated practices that increase the transparent reporting of management results. One venue might be to develop a small suite of indicators of the application of evidence-based information that could be incorporated into national/provincial/territorial reporting on protected areas. Reference has been made to reports issued by the Auditor General regarding resourcing of National Parks. Subsequent editions of reports such as the *Canadian Protected Areas Status Report 2012–2015* issued by Environment and Climate Change Canada (ECCC) (2016) might also include more content on management effectiveness. Likewise, the Conservation Areas

Reporting and Tracking System (CARTS), jointly administered by CCEA and ECCC, could consider adding new fields to this national database to reflect efforts to enhance evidence-based practice in the protected areas sector.

Evidence-based protected areas management requires the collection and analysis of valid, objective, and impartial data regarding past activities, ultimately with the goal of applying this knowledge to decision-making about the future. This is the essence of adaptive management, which involves a cycle of planning, implementing, monitoring, evaluating, and adapting actions to improve outcomes. While evidence-based decision-making is regarded as beneficial to adaptive management (Allan and Stankey 2009), our results strongly suggest that the potential benefits (i.e., enhanced management effectiveness) of evidence-based approaches and information are not being maximized in Canada's protected areas organizations. Consequently, inappropriate or inefficient management practices may be implemented. Aichi Biodiversity Target 18 (UNEP 2010), for instance, calls for full integration of Indigenous knowledge relevant to conservation and sustainable use in the implementation of the United Nations CBD. However, our findings identify a lack of use of Indigenous knowledge and local knowledge among protected areas managers in Canada, with potentially disadvantageous consequences for the implementation of conservation policies, plans or actions, including weaker protection of cultural, social, and ecological assets.

Conclusions and recommendations

While it is beyond the scope of this article to address the comprehensive suite of future needs for evidence-based decision-making in Canada's protected areas organizations, we conclude by proposing several essential factors that need to be introduced or improved to remove institutional barriers and enable a more widespread use of the many forms of evidence required for effective management.

First, there is a clear need to enhance funding for research, monitoring, and knowledge mobilization activities related to conservation management and practice within the protected areas community. We recognize that effective protected areas management involves a broad and dynamic community, including government institutions and personnel (those with formal and legal responsibility for managing protected areas), land and marine stewards (primarily non-governmental actors engaged in managing protected areas, such as Indigenous peoples and community groups), and influencers (entities or groups who influence the capacity to manage protected areas, such as the academic research community). Funding will be essential to enhance capacity at all levels, and ideally research will seek to bridge the knowledge of these different communities.

We recognize that the recommendation to enhance funding for management and practice research is not new. However, it is highly relevant in the Canadian conservation context. Understanding ecosystem conditions and the impact of protected area management interventions on conservation outcomes has been impeded by a lack of data (Federal, Provincial, and Territorial Governments of Canada 2010; Coad et al. 2015). Spending on conservation practice in Canada is very low in terms of relative public investment, and funding available for research is lower still. Currently, there is no national leadership for conservation research, and funding is fragmented across sponsors with poor communication and coordination, including between and within levels of government and the broader community defined above. Geldmann et al. (2015) found that when funding and resources are targeted at protected areas under greater "threat" (e.g., road and human population density), they have a greater impact on conservation outcomes, potentially including slowing the loss of biodiversity. While costs for producing evidence may be high, it is imperative that organizations allocate more funding for research that creates evidence relevant to agency conservation objectives and by extension management effectiveness.

Second and relatedly, to be more effective the research community must quickly redirect research to better match conservation priorities (Lawler et al. 2006). Our results indicate that managers perceive a significant disconnect between the production of evidence and their ability to utilize evidence in a timely fashion to inform management (**Supplementary Material 2**) (see also Cvitanovic et al. 2016). The communication of research and monitoring data between conservation stakeholders has generally been regarded as poor (e.g., Gibbons et al. 2008), and some have even claimed that the science–policy relationship is "dysfunctional" (Sutherland et al. 2012). While a significant proportion of the research funded in Canada, through Canada's tri-council funding agencies for instance, is intended to be management relevant, evaluation of evidence uptake and impact on policy and management has been neglected in academia (see Gibbons et al. 2008; Arlettaz et al. 2010 for useful discussions). Some have argued that academics tend to miss the chance to influence policy and management with their findings (Dicks et al. 2014). For instance, academic results are often communicated on a timeline that responds to academic norms rather than the needs of the policy cycle or lack a long term, consistent monitoring and reporting framework—all of which limit the transferability of key lessons. Furthermore, Canada does not have a single Research Chair who focuses on protected areas management and there are no Networks of Centres of Excellence (NCE) with a protected areas management focus[4]. This lack of action is somewhat perplexing given Canada's international commitment to conserve 17% and 10% of terrestrial and marine area, respectively, by 2020. If these goals are achieved, protected areas would represent the largest land use designation in Canada.

For adaptive management to be effective, scientists, managers, and the public need to better understand one another's perspectives. Timely partnerships, frameworks, and models of consultation to facilitate knowledge exchange will be required to encourage greater participation of "end-users" in defining the scope and objectives of research programs (Pullin and Stewart 2006; Gibbons et al. 2008; Cvitanovic et al. 2014, 2016; Reed et al. 2014). Scientists need to move beyond simply critiquing existing policy to framing and communicating evidence in terms of practitioners' needs. Built on a model of evidence-synthesis associated with the "effectiveness revolution" in the medical sciences, the Collaboration for Environmental Evidence (CEE) supports the development and dissemination of open-source systematic reviews that examine the effectiveness of conservation interventions (Keene and Pullin 2011; Collaboration for Environmental Evidence 2017). The CEE is an example of how researcher–practitioner partnerships can contribute to the synthesis of existing research in support of conservation practice. Similar collaboration earlier in the research chain will help increase the body of primary research that is designed to collect evidence relevant to practice (Berkes 2007; Armitage et al. 2012; Cvitanovic et al. 2013).

Finally, we support the conclusion of Armitage et al. (2011) who found that managers may be overly cautious about how they react to Indigenous knowledge. Canada has stated that Indigenous protected areas will be used to help meet the international goal of conserving 17% of its terrestrial area by 2020, signaling a greater role for Indigenous peoples in creating and managing protected areas. However, at present our results indicate a relatively low perceived value and use of Indigenous knowledge across the protected areas sector. Addressing this gap in organizational mandates and organizational norms is an important priority. Effective collaboration in the design and management of protected areas can serve an important role in Canada's ongoing reconciliation efforts. Moreover, evidence suggests that the process and linkage functions of co-management with Indigenous peoples can build adaptive capacity at multiple levels by accessing place-based knowledge, fostering shared understanding and sense-making, and increasing dialogue and interaction (Tipa and Welch 2006; Armitage et al. 2011).

[4]Funded by the Government of Canada, these centres focus on creating partnerships and working with end-users to accelerate the creation and application of new knowledge.

Some efforts on this front are being made at the federal level, where the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) has prepared *Aboriginal Traditional Knowledge: Process and Protocols Guidelines*. The guidelines outline an approach as well as specific steps to facilitating access to and the gathering of the available Aboriginal Traditional Knowledge (ATK) as well as the incorporation of that knowledge into the COSEWIC species status assessment process (COSEWIC 2018).

To contribute to reconciliation and adaptive capacity, processes must begin with an acknowledgment of the high value of Indigenous knowledge to effective conservation practice, and an understanding of and commitment to the principles and protocols that are specific to Indigenous people's history, territory, and people (Tipa and Welch 2006; Matunga 2013). Of particular note is the recent development of the *Conservation 2020: Pathway to Canada's Target 1*, which is a national forum of federal, provincial, and territorial protected area organizations, and environment and Indigenous peoples (Canadian Parks Council 2016). This forum has been convened to provide leadership and guidance on Canada's efforts to achieve its commitment to Aichi Biodiversity Target 11 (UNEP 2010), and Indigenous leaders will provide key recommendations for achieving this target to federal, provincial, and territorial ministers. Seven expert task teams will generate reports on topics including "defining protected areas", "Indigenous conservation areas", "ecological representation", "connectivity", "equitable management" and "measuring management effectiveness". The template adopted for the Pathway signals a desire to engage a broad constituency to tap knowledge and expertise beyond the protected areas sector and could provide a model for longer-term engagement and collaboration (Canadian Parks Council 2016).

Protected areas are critical to conserving biodiversity on terrestrial and in marine areas when they are managed effectively (e.g., Edgar et al. 2014). However, conservation decision-making in support of management effectiveness is extremely complex. Our results suggest that reform is required to improve use of multiple forms of evidence in decision-making aimed at securing conservation outcomes. If protected areas management truly seeks to be effective, adaptive, and informative, then various forms of evidence must be used at the outset and throughout planning and management processes (Holling 1978). There is a role for research in the task of outlining how to best pursue this complex task. However, it will ultimately be up to the leaders of protected areas organizations to push for an organizational culture where managers are motivated and enabled to apply multiple forms of evidence to advance decisions that yield meaningful conservation outcomes.

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Author contributions

CJL, SB, and TJB conceived and designed the study. CJL performed the experiments/collected the data. CJL, MWG, SB, and TJB analyzed and interpreted the data. CJL, MWG, SB, and TJB contributed resources. CJL, MWG, SB, and TJB drafted or revised the manuscript.

Competing interests

The authors have declared that no competing interests exist.

Data accessibility statement

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

Supplementary material

The following Supplementary Material is available with the article through the journal website at doi:10.1139/facets-2017-0107.

Supplementary Material 1

Supplementary Material 2

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