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Knowledge Mobilization in the Beaver Hills Biosphere, Alberta, Canada

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Abstract: This study explores how knowledge was and is mobilized to advance the objectives of the Beaver Hills Biosphere Reserve, located in Alberta, Canada. Established in 2016, a 12-year collaborative effort worked to establish the biosphere reserve and achieve formal UNESCO designation. Subsequent efforts to grow the newly established biosphere reserve have accelerated in recent years. Our study documented how different types of knowledge were accessed, created, curated, and shared between partners during these two time periods. Focus group interviews were conducted with 14 participants, who are affiliated with Beaver Hills Biosphere Reserve partner organizations, and revealed the following findings: (1) not all knowledge is equally valued or understood; (2) partnerships are highly valued, and were essential to successful knowledge mobilization, but were stronger among individuals rather than organizations; (3) fear of the loss of autonomy and potential complications due to the establishment of a biosphere reserve slowed the exchange of information and engagement by some regional actors; and (4) knowledge mobilization is and was impeded by staff and agency capacity, finances, and time scarcity. This was further complicated by entrenched norms of practice, existing successful working relationships impeding the development of new partnerships, and embracing alternative forms of knowledge.

Keywords: knowledge mobilization; social science; natural science; local knowledge; traditional knowledge; indigenous knowledge; parks and protected areas management; biosphere reserve

1. Introduction

Biosphere reserves, whose objectives include biodiversity conservation, sustainable development, and capacity building in support of education, research and learning, provide a rich context in which to study knowledge mobilization. Centered on protected areas with strong preservationist and conservation goals, biosphere reserves lie within highly modified landscapes that host evolving and diverse livelihood activities and complex human–environment interactions. Typically, biosphere reserves are managed regionally, by park and other governmental agencies, environmental non-government organizations (ENGOs), research institutions and other partners. Biosphere designation recognizes the capacity to share and generate new understandings of the socio-economic and natural aspects of the landscape among these partners, to achieve regional, coordinated land management through collaboration. This complexity demands the application of different types of knowledge to achieve sustainability and ensure the continuity and celebration of the "sites of excellence" contained within these biosphere reserves. Studying how knowledge is mobilized

to achieve biosphere reserve objectives can support the efforts of partners engaged in the collaborative management of biosphere reserves, and is the focus of this paper.

Knowledge mobilization is defined here as the movement of knowledge into active service for the broadest possible common good [1]. Knowledge may include findings from natural and social science studies, or humanities and arts-based research, the accumulated knowledge and experience of these researchers, or the accumulated knowledge of stakeholders and rightsholders concerned with the issues that the knowledge is being mobilized to address [1–4]. Knowledge exchange [5] is a term that is frequently used by environmental management researchers to represent similar actions and meanings. A wide range of activities can be encompassed by knowledge mobilization, but may include knowledge transfer, knowledge translation, knowledge management, knowledge production and creation, and knowledge action [3,4]. In this paper we discuss knowledge that is generated through scientific methods, informed by disciplinary traditions of agreed to principles or processes of study, including reliability and validity [6]. We also include other ways of knowing about the landscape, including the local experience of recreation, work, and residence within a specific ecological setting [3,7,8], traditional ecological knowledge (TEK) [9], and Indigenous knowledge. We consider local knowledge as distinct from TEK in that "the former has been derived from more recent human–environment interactions (e.g., a few generations) rather than being embedded in deeper cultural practices" [6]. We define Indigenous knowledge as local knowledge held by Indigenous peoples, or local knowledge unique to a given culture or society [10]. We acknowledge that Indigenous knowledge and TEK share characteristics, yet TEK has an explicit ecological emphasis [11].

1.1. Study Objectives

Through this study, our research team documented the diverse experiences of agencies and partners within the Beaver Hills Biosphere (BHB)[1], in their engagement with different forms of knowledge. The BHB provided an excellent case study location, given its structure and governance. The group includes federal and provincial park agencies and five municipal governments who manage lands within the BHB, as well as research, ENGO and industry organizations with active interests in the landscape. The BHB is a voluntary collaboration of these partners, and members participate as time and capacity allows, on working groups and projects contributing to regional and more localized management objectives. Such projects offer the potential to share knowledge generated and maintained through social and natural science, as well as Indigenous (i.e., Canadian First Nations and Metis), traditional ecological and local knowledge systems. We asked how park and conservation agencies, as a central component of biosphere reserves, as well as other land managers within the BHB, such as municipalities and NGOs are able to (or not) access knowledge when making management decisions. In addition, we focused on how the Beaver Hills Initiative (BHI) in particular used knowledge to create a biosphere reserve, inclusive of its eventual successful designation in 2016 (i.e., the BHB), supported by the knowledge mobilization efforts of its partners and how being a biosphere reserve allows for the ongoing use of knowledge mobilization amongst partners.

Study findings highlight some of the challenges and successes the biosphere reserve partners have experienced when it comes to knowledge mobilization. Our observations will assist the BHB, other biosphere reserves, and similar collectively managed landscapes in their efforts to achieve more effective and efficient [5] knowledge mobilization to attain sustainability and sustainable development.

1.2. Literature Review

Parks and protected areas must manage for a diverse set of goals, including protection, conservation, and visitor enjoyment [12]. The majority of parks-related scientific effort has focused on the monitoring

[1] The Beaver Hills Biosphere has chosen to call itself a "Biosphere", not a Biosphere reserve. We have therefore chosen the acronym "BHB" for the Beaver Hills Biosphere and will refer to Biosphere Reserves in more generic applications.

and management of natural systems and elements within park boundaries, e.g., [13]. However, the protection of this natural heritage is intertwined with economic, social, and cultural interests, within and adjacent to their boundaries, and thus, park managers must access and use knowledge from a wide variety of disciplines outside of their normal information sources to make effective management decisions [14]. Unfortunately, the use of Indigenous [15–18], local [6,19,20] and social science [21,22] sourced knowledge to inform park and larger ecosystem management efforts remains limited.

Environmental management and park-related knowledge mobilization challenges have been documented previously [5,23,24]. However, this dialogue has largely focused on the use of natural science research and achieving nature conservation rather than other mandates such as social benefits. The importance of social forces that affect environmental and park management has been documented by park researchers [25,26], practitioners [27–30], and overviews of social science in conservation efforts [4,14,21,22,31,32].

In Alberta, a recent research priority setting exercise emphasized the need for social science research in protected area management [33]. Based on a series of regional and provincial workshops with parks staff and experts, 64% of the questions generated related to social science topics (including policy and economics). This trend is not unique to Alberta [22,34] or to protected areas [32]. Key gaps include an understanding of the processes that can facilitate knowledge creation and exchange [2,5], including interactions between actors [4], and the role of context as an influence on that process [2,4]. These researchers and others call for study further study of the factors that shape knowledge mobilization, including its creation, management, sharing, use.

In making decisions, many studies show that people and agencies more often draw on intuition, personal experience, collective experience, and other types of informal knowledge, rather than on empirical or evidence-based information [35,36]. Critical barriers have been identified as inhibiting knowledge exchange among scientists and decision-makers involved in land and park management [2,21]. These barriers include the inaccessibility of science to decision-makers, poor communication among knowledge generators and potential users, inadequate training, as well as capacity issues and cultural, institutional and personal perception (worldview) barriers that limit the extent to which scientists and decision-makers can participate meaningfully in knowledge exchange activities [2,35,37,38]. In Canadian parks, the top barriers for accessing and using evidence for management and planning were limited financial resources, lack of staff, lack of time, inadequate timeframes for decision-making, lack of monitoring programs, and the disconnect between researchers and decision-makers [39]. Barriers to knowledge mobilization will vary by type of knowledge (e.g., for Indigenous knowledge see [15–17] and, for local knowledge studies see [17,20,40]). Generation of, access to, and use of knowledge derived from Western science (natural or social science), local, or Indigenous knowledge are characterized by different barriers and potential solutions.

Various solutions have been proposed or used to mobilize knowledge more effectively and efficiently. These include educating knowledge generators about the policy-making process, educating decision-makers about the research process, reforms to institutional environments, using knowledge brokers, establishing job exchanges, and other informal mechanisms to share ideas (e.g., workshops, training events, and brainstorming sessions) [2,41].

1.3. Biosphere Reserves

UNESCO's biosphere reserves are areas designated based on their high social and ecological significance and their capacity to demonstrate sustainable development principles. Introduced under the UNESCO Man and the Biosphere (MAB) Programme in 1969, biosphere reserves are settled landscapes, with a core protected area or areas surrounded by a buffer zone of lower impact land use and beyond that, a transition area with higher levels of human activity. Importantly, these are areas where people live and work within a natural landscape: sustainable development is a key goal of land management in all zones, and requires collaborative land management among land management

agencies. Globally, there are 691 reserves in 124 countries that form a World Network of Biosphere Reserves, including the 18 sites distributed across Canada [42].

Successful biosphere reserve nominations must meet the goals of the MAB Programme to provide key functions of biodiversity and cultural conservation, sustainable development, research, and education [43]. Further, biosphere reserves must be managed under an established system of regional governance capable of creating and sustaining on-going programs to deliver these functions. Established biosphere reserves are now evaluated every 10 years to measure their progress toward the MAB goals, expressed within specific Action Plan objectives intended to address topical issues (e.g., climate change), or to ensure balance among the biosphere reserve functions. Past Action Plans have focused on initiatives resulting from United Nations Conferences on Environment and Development (UNCED) meetings, including the 1992 Rio de Janeiro meeting that resulted in the Convention on Biodiversity, UN Framework Convention on Climate Change, and 'Agenda 21' [43]. They have also emphasized improved functional elements of biosphere reserves, informed by global assessments of the progress of biosphere reserves toward MAB goals.

Key policies guiding these evaluations include the 1995 Seville Strategy and the Statutory Framework that now guide biosphere reserve designation, management, and evaluation [44]. Critically, Article 9 of the Seville Strategy allows Member States of the UNESCO MAB Programme to withdraw biosphere reserves that do not meet the criteria of sustaining both the three biosphere reserve zones and a functional governance system. The 2008 Madrid Action Plan added additional, specific targets relative to climate change, the increasing loss of biological and cultural diversity and urbanisation, and the Millennium Development Goals (2000). The current MAB Strategy (2015–25) and Lima Action Plan (2016–25) build on these objectives and emphasize the need for biosphere reserve to focus on five strategic areas: (1) biosphere reserves as sites demonstrating effectively functioning models of sustainable development, (2) collaboration and networking, (3) partnerships and sustainable funding, (4) communication, information and data-sharing, and (5) governance.

Functional biosphere reserves rely on effective collaboration and measurable progress toward sustainable development goals. The current policy objectives address complex, 'wicked' problems that require pooled knowledge and expertise, as well as cooperative management strategies. biosphere reserves are implicitly founded on inter-disciplinary and trans-disciplinary approaches that such sustainability problems demand, yet their effectiveness in promoting this aspect of sustainability science is little understood [44]. The MAB Strategy (2012–25) now emphasizes sustainability science, and its unique, integrated problem-solving approach, drawing on a full range of scientific, local, traditional and Indigenous knowledge as a key means of achieving sustainable development through biosphere reserves. Further, the Strategy emphasizes the roles of coordinators, managers and scientists associated with biosphere reserves in operationalizing and promoting such approaches within their sphere of influence [44].

The Beaver Hills Biosphere (BHB) provided a relevant location for a case study exploring knowledge mobilization in the context of sustainable development. The 1600 km^2 Beaver Hills Moraine is a distinct ecological area, with rolling hills, abundant wetlands and forests, located immediately adjacent to the Edmonton Capital Region, one of the fastest growing metropolitan areas in Canada. It has over a century of conservation history, resulting in several federal and provincial protected areas embedded in a mixed agricultural and rural residential landscape, and a strong community, government and institutional interest in protecting this unique area from urban expansion [45,46].

The Beaver Hills Biosphere was designated in 2016, 12 years after the organization of its regional management board (the Beaver Hills Initiative, BHI). The board comprises representatives of federal, provincial and municipal government agencies, academic institutions, environmental non-governmental organizations industry, each with land management interests in the Beaver Hills moraine. The success of the BHB lies in its governance. The municipalities and park agencies retain independent jurisdiction over their respective lands, and participation by all partners in the group is voluntary. The BHB (and the BHI before it) offers the potential for shared resources, collaborative

research and joint management programs where relevant to the respective agencies, but the BHB cannot require participation by any of its members. Critically, it must also involve local and Indigenous interests in management of the biosphere to meet designation requirements, but must recruit such involvement. Although the moraine was an important place for Indigenous peoples historically, reserves created in the late 1800s and settlement by Europeans, severely disrupted those ties. Restoring a relationship with local Indigenous communities has been a key challenge for the BHB, as well as addressing urban development, climate change and other sustainability concerns. With its first 10-year evaluation coming in 2024, it was timely to evaluate the progress of the BHB toward the Lima Action Plan (2016–2025) and in particular, its effectiveness in mobilizing the collective knowledge and expertise held by its members towards these sustainability goals. Since knowledge mobilization in the BHB relies on the willing participation of individual participants and their home organizations, barriers become even more evident.

2. Materials and Methods

Research design and project methods were guided by knowledge mobilization research questions posed in biological, ecological and conservation-related refereed literature, e.g., [5,6,24,33]. Proposed principles that can and should shape knowledge mobilization processes [47,48] also informed study design. These included Nguyen et al.'s [4] Knowledge–Action Framework and Bennett et al.'s [21] Framework for Collaborative and Integrated Conservation Science and Practice. We also recognized high levels of interconnectedness among all participants in the effort to translate knowledge into practice [49].

Recognizing the interconnectedness and complexity of the case study site, we approached this research through qualitative methods, as they are ideal to explore topics where little is known, make sense of complex situations, gain new insights about phenomena, construct themes in order to explain phenomena, and ultimately foster a deep understanding of the phenomena [50]. As researchers, we employed a pragmatic research paradigm to this study. Pragmatism, while relatively new to conservation literature, is a philosophy based on common sense, that simultaneously is dedicated to the transformation of culture, and to the resolution of the conflicts that divide philosophers and researchers alike [51]. Within this philosophical worldview we believe that in the single reality of the world with multiple perspectives and experiences of that reality, knowledge is therefore constructed and based on that reality [52].

Pragmatism reminds us that research questions are not inherently "important," and methods are not automatically "appropriate" [53]. Instead, it is we as researchers who make the choices about what is important and what is appropriate. Hence, our research goal of understanding how the BHB used knowledge to create a biosphere reserve, and continues to mobilize knowledge for effective conservation and land management practices through voluntary collaboration lends itself to a qualitative case study approach.

This study followed a case study approach [54] to further examine biosphere reserve actors' views regarding the use and access to biosphere reserve-relevant knowledge. Case studies are an effective method when research is exploratory, explanatory, and/or descriptive [54]; as such, this case study was an effective method for understanding and exploring the experiences of the various actors within the BHB and knowledge mobilization. This particular case study is a part of a broader research project partnership, focusing on knowledge mobilization in parks and protected areas. The research partnership includes park and conservation agencies and universities from across Canada. The BHB was chosen as it is uniquely positioned for such an assessment, given the objectives of knowledge sharing within a biosphere reserve to inform sustainable development, and the need of the various actors and partner agencies to exchange social, natural and cultural knowledge in order to achieve the biosphere reserve goals. Biosphere reserve actors will continue to require a knowledge-based approach to achieve their own goals, as well as to advance the biosphere reserve objectives, but must do this through voluntary, rather than mandated arrangements for sharing and co-production of knowledge.

We reviewed grey and peer-reviewed publications about research and decision-making in the BHB. Next, we developed a set of interview questions focused on respondents' experiences with different forms of knowledge (social science knowledge, natural science knowledge, Indigenous knowledge, traditional ecological knowledge and other forms of local knowledge) and how agencies are able to (or not able to) access knowledge when making management decisions (see Appendix A for complete list of questions). In addition, we focused on how the BHB in particular used available forms of knowledge (e.g., natural, social, local and Indigenous) to create a biosphere reserve supported by the knowledge mobilization efforts of its partners and how being a biosphere reserve allows for the ongoing engagement in knowledge mobilization amongst partners.

2.1. Sampling

This study followed purposeful sampling as described by Creswell and Poth [55] in which the researchers select individuals and sites as they can purposefully inform understanding of the research problem and central phenomenon of the study. Within purposeful sampling, Creswell and Poth describe various types of strategies; this study followed maximum variation so as to document diverse variations of individuals and partners within the BHB. We attempted to interview leaders and influential members of partner agencies and organizations within the BHB who were familiar with the designation process and subsequent activities of the BHB, recognizing that there are no set criteria for sample size within qualitative research. Our goal was to understand the case in rich detail, and with continuity across designation through operation phases of the BHB, and have representation from the various organizations. Criteria for the sample included all BHB partner organizations who have had or currently have influence over and expertise in land management within the BHB, and were familiar with the designation process and transition into the BHB.

The BHB Board includes representatives from local municipalities (Beaver County, Lamont County, Strathcona County, Leduc County), federal park staff working at Elk Island National Park, provincial park staff employed by Alberta Environment and Parks, researchers based at the University of Alberta, and NGO representatives from Alberta Fish and Game Association, Alberta Lake Management Society, Beaver Hills Dark Sky Preserve, Canadian Parks and Wilderness Society, Ducks Unlimited Canada, Edmonton and Area Land Trust, Friends of Elk Island Society, Land Stewardship Centre of Canada, Miistakis Institute, Nature Alberta, Nature Conservancy of Canada, North Saskatchewan Watershed Alliance, and the Royal Astronomical Society of Canada. Not all current representatives to the BHB Board have been involved over sufficient time to meet criteria for study participation. Indigenous groups and governments are not currently on the Board, but have worked with the BHI toward biosphere designation. They, and local landowner associations, were invited to participate but representatives were not available for engagement.

We invited 21 candidates to participate in the study. Fourteen participants agreed to participate; others declined for logistical and timing reasons. From January to September 2019, we conducted seven focus group discussions (five in person at the University of Alberta and Miquelon Lake Provincial Park and two by phone). Group size in the discussions ranged from one to four individuals. Focus group arrangements were based on location and availability of participants, and in some cases, were based on agency representation (i.e., municipalities in one focus group, provincial agencies in another). The two one-on-one interviews were conducted with academics who have been involved with the BHB for over 15 years and provided in-depth expertise to the UNESCO Biosphere application as well as many future land management documents and policies. The one-on-one format allowed for transparency and anonymity. The discussions ranged in length from 61 to 126 minutes.

2.2. Analysis

Guided by Braun and Clarke [56], this study followed a thematic analysis approach. Thematic analysis is a method for identifying, analyzing, and reporting patterns (themes) within data. It minimally organizes and describes the data set in rich detail. However, it goes further than this and

interprets various aspects of the research topic [57]. This process follows an inductive approach to coding and development of themes, meaning that the themes identified are strongly linked to the data themselves [58]. This approach involved reducing the empirical material into categories guided by the participants' narratives without losing sight of the research aims, a process which allowed for the identification of emergent themes [59]. Thematic analysis follows a six-step approach as described by Braun and Clarke, the process followed by the research team is outlined in Figure 1 [56]. Phase one begins with familiarizing yourself with the data; in this phase, all audio recording of focus groups and interviews were transcribed, and each author read and re-read the transcripts. Phase two involved the authors generating initial codes using NVivo 12; the ideas captured in the focus group discussions were coded in an iterative process. During the third phase the research team began discussing and searching for themes by re-focusing the analysis at the broader level of themes, rather than codes. This involved sorting the different codes into potential themes and collating all the relevant coded data extracts within the identified themes. Phase four allowed for the authors to review themes, remove, and combine as necessary, and reflect on the inductive process by considering why the data were within the theme. Phase five allowed the research team to define and name themes, while keeping the perspective that themes do not have to be what is talked about the most, but rather should be a reflection of what is important and interesting in relation to the research questions and the data themselves. Phase six of the thematic analysis process focused on crafting this manuscript and selecting quotes to support the themes. After triangulating our respective individual interpretations from this process, further joint discussion facilitated the development of the interpretations that follow.

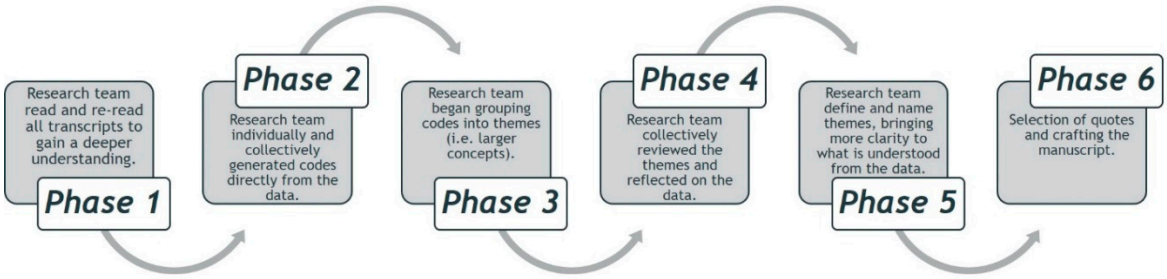

Figure 1. Phases of data analysis.

3. Results

In this section, we present how knowledge was described, understood, and used in the creation of the Beaver Hills Biosphere (BHB) and the ongoing partnerships within the BHB. Overwhelmingly participants acknowledged the contribution of scientific studies to planning and management activities in the BHB, whilst also recognizing the plurality and tensions within the various conservation agencies and the field more broadly when it comes to the creation, application, curation, and storage of knowledge.

3.1. All Knowledge Is Not Equally Valued or Understood

While many, if not all conservation agencies, including those who represent the BHB, noted the use of evidence-based decision-making practices, our findings reveal that evidence utilization is subject to availability, accessibility, and preference in most instances. Rather than utilize the most appropriate, holistic or robust knowledge, partners in the BHB still appear to turn to knowledge that they are most familiar with and avoid or undervalue other forms of knowledge. For example: *"Both with the BHI and with environmental planning in Strathcona [County] we don't really focus on social science; we rely more on natural science. Like if we are talking about the interactions with people and the environment there is no study that we are basing it off of, to me it's just common sense" (Municipality #1).*

One respondent described the interplay between land use planners and ecologists in the creation of the BHB's Land Management Framework, a foundational document to the BHB's designation.

During development of the framework, the value of social science compared to natural science was questioned: *"the recognition of the value of [social science] in the land management framework, which was very much seen as being a tool to facilitate more informed decision making by the five counties is very strongly by physically base. And the marine report, which is very comprehensive in terms of the biophysical and I use that term in the broader sense of the term, and what is covered in the socio economic [social sciences] is dare I say pretty rudimentary. a lot of my experience has been in the land use planning side of things . . . " (Academic 1).* The value of social science is downplayed as "common sense" rather than considered a scientific discipline with training, expertise, and merit in management scenarios.

Even when social science is conducted within the BHB, the application of findings and the ability to effectively mobilize social science knowledge is not realized; for example, "*Now there were people like you who have done studies dealing with some of the [human] behavioural elements and stuff like that. But it hasn't been incorporated at this point in time in terms of major decision making and the future the biosphere reserve" (Academic #2).*

The idea that knowledge is supported by science or evidence is not untrue; it appears, however, that science typically refers to natural science. The use of social science is largely underutilized, misunderstood, and seen as costly or time consuming within the BHB. Many actors within the BHB struggle to identify what social science is, identifying visitor satisfaction surveys or public consultation as examples of social science, but unable to elaborate. For example: *"I think a lot of natural scientists look at that and go, it's pretty easy to catch a fish, measure it, release it, etc. But getting into peoples' behaviours and why they love fishing, holy moly, that's hard, I'm going to leave that alone!" (Park Agency # 4).* However, natural science appears to be highly valued, relatively easy to access, and support: *"I think natural science can definitely be worked in [to park/land management practices] easier. We claim we are science-based decision making so I guess it's easier, but I think natural science [is easier], I mean people expect that when they come to a park." (Park Agency #5).* Natural science is better understood and is communicated to politicians and decision-makers more often as it is considered more tangible and quantifiable: *"I'd say the physical sort of biological sciences are easier for us, most of us have a background and they're easier in some way to measure."* (NGO#3)

This bias is not just driven by individual preferences or training, but also agency traditions; focus group participants acknowledged it would take a major incident to inspire use of 'other' knowledge:

- Interviewer: *So what would it take for social science and local or indigenous knowledge to be fully integrated [into management practices]?*
- ParkAgency 5: *maybe a crisis, unfortunately.*
- Interviewer: *Like injury or death?*
- ParkAgency 6: *Yeah or something that is a game changer.*
- ParkAgency 5: *A hunting accident, or a nice dog walker being shot by a hunter, now we get the money and attention to deal with it. It's a horrible way to do business but . . .*
- ParkAgency 6: *Well yeah it's reacting again, we could spend days and months and years talking and no one is going to listen until something happens.*

Furthermore, as Canada searches for meaningful reconciliation between colonial settlers and Indigenous peoples, the value of traditional and Indigenous knowledge is beginning to be considered in BHB management and practices. However, that same knowledge was critically missed in the BHI's first attempt to be designated a biosphere reserve: *"The first time the BHI nomination went in for designation as a biosphere reserve, it was totally silent on Indigenous use of this landscape except in a historical context" (Academic #1).* While this realization led to many months of research and extensive historical exploration to ensure accurate and authentic representation was made in the subsequent application document, it does not appear to be understood and used in the same manner as other forms of science and knowledge. In part, this may stem from a lack of understanding among decision-makers of

how Indigenous knowledge is shared, compared to Western science, and a need to rebuilt trust with potential Indigenous partners. One park agency described:

"You can spend an awful lot of time with Indigenous people in the field and get invited to sweat but you've really got nothing to show for it – there is no widgets at the end to say I produced this thing, you may reap the benefits in 5 years time and that's sometimes hard for managers and directors to say we poured $150,000 into this, what did we get out of it? Well I went on a sweat and I went to the pow wow and we're friends now and that's hard to justify to the public, but we well know there are benefits. So 3, 4, 5 times meetings would go beyond the hours of what they had costed out. You just have to appreciate that it is different, and you need to understand that. It takes time and you may not have a widget within the first year or the second, but five years down the road you are getting something out of it and the appreciation of that and little things" (Park Agency 4).

The BHB and partner agencies also recognize the challenge of integrating traditional and Indigenous knowledge into management decision making and knowledge mobilization. Canada is still grappling with the effects of colonialism on Indigenous societies and cultures. *"The Truth and Reconciliation committee is really a big challenge, Strathcona [County] doesn't have an overall policy or advisory statement and neither does the BHI at this point, although that's a target with some funding attached, so work has been done." (NGO #2).* A park agency employee summed up current practices with the following statement: *"Honestly, with Indigenous knowledge, I don't have much experience because that is usually not really accessible, I get more from historical resources and books." (Park Agency #6)* Accessing Indigenous knowledge related to the Beaver Hills is a challenge, in part due to the historical displacement of Indigenous peoples from the moraine. However, this may also indicate a lower value attributed to lay knowledge, relative to natural or social science. Focus group participants rarely spoke to other sources of Indigenous or local knowledge, such as landowners' or long-time recreational users' insights.

3.2. The Potential Value of Partnerships

Knowledge can be informed by various sources, including non-traditional sources. Partnerships allow access to these information sources. Participants reflected on how integral partnerships and "outside" sources (i.e., outside their own agency) were to accessing and generating information, highlighting the value of the BHB and the relationships developed through the creation and ongoing work as a biosphere reserve. Many BHB agencies commented on how participating in the biosphere reserve development process improved their ability to access knowledge even within their own organization:

". . . to mobilize knowledge internally, I seek those opportunities out [when] training seasonal employees, the firearms instruction crews, [mixing] fisheries researchers with bios, getting into Cooking Lake Blackfoot and actually meeting the people there now I know if I need to mobilize knowledge from these people they're not just someone with an Outlook email address, I can actually reach out to [Joe So-and-so] or whoever and I can ask them, [I need a solution for] enforcement challenges in X, and they know who I am. It's like hey how are you doing? I'll share this information rather than here's some dude who works for the division but he is in Edmonton and 'I don't know with your esoteric questions.' So they are more likely to relate to that, so I think that in terms of mobilizing knowledge works better within an organization." (Park Agency 4)

External agency relationships within the BHB partners are also a direct result of the biosphere reserve designation process. ". . . and then externally, meeting Parks Canada people, working with the Land Stewardship Centre, or Nature Alberta, or ECA—those personal relationships are invaluable in actually mobilizing good knowledge sometimes." (Park Agency #4). External partnerships allow for easier access to knowledge, which in theory makes it easier to mobilize, and for some partners in the BHB (mainly the smaller organizations), this seems to be a tremendous benefit, "I found the open sharing within the Biosphere in the initiative has been really nice and I know that that data report that was done in 2015 is really good for getting a general sense of data within the region, especially very locally." (NGO #4). Reading through focus group transcripts, we wonder, however, if the external partnership benefits are strong and meaningful or if they are perhaps more surface level. It appears to be mainly agency staff and politicians with experience of working with the BHB who embrace the

partnerships rather than their fellow colleagues and organizations. It is for this reason we feel that partnerships have the potential to be incredibly valuable but do not appear to be fully capitalized.

3.3. The Reality of Partnerships

Partnerships and collaboration only work when all parties are engaged and participate; whilst external partnerships are the strength and purpose of forming the BHB they do not always come to fruition nor are they welcomed by all. For example: *"With the FireSmart plan, we said as the BHI we are paying for this work, do you want to be included? We thought it was like a no brainer, but we had one county who refused, we couldn't get them on board." (Municipality #1)* The information developed in this project [FireSmart Plan] provided an understanding of fire risk and prevention measures in the moraine, but it may not have been equally valued by, or immediately useful for all partners. Yet if shared with all regional land managers and owners, it could have reduced risk of wildfires increasingly prevalent with climate change. The need to show the utility of information to encourage use by partners was highlighted by another participant, who said: *"We just got a bunch of information sitting around, and we are not talking to each other, right. And then I think at some point it'd be good to have projects that utilize that information that you have somebody that goes in there and pulls information down and does some kind of meta-analysis or something uh even for some of the indicators that we had in the Beaver Hills report maybe a reason for that." (NGO #3)*

Furthermore, the struggle to create meaningful partnerships was a factor right from the beginning. As discussions commenced regarding the establishment of the biosphere reserve, control was an imposing barrier. Some agencies were worried about giving up control while others were clearly seeking to share management responsibilities and strategies. For example: *"I think a lot of the stumbling blocks and time wasted, I think there was always, particularly from the elected officials' side, concerns that the BHI would become a decision making body as opposed to a facilitator, providing a range of tools, and being able to implement and use those tools to the betterment of the broader interest. So that was one of the biggest problems um I think uh depending on the people around the table the effectiveness of them and the agency or interest they represented depended very much on those people." (Academic #2).*

Regional partners did not want another decision-making body, telling them what to do, and feared the BHI and later the BHB would assume that role, adding another layer of bureaucracy to the region, and reducing the autonomy of smaller municipalities and organizations. This is well represented in the narrative below which details a small municipality's reticence to become a formal partner in the biosphere reserve: *"I remember going to Camrose Council and a counselor that was pretty resistant to the whole BHI idea. Initially, someone had said the words biosphere reserve and it triggered a whole negative response and backlash really. He spent a whole council meeting in that part of the BHI presentation trying to barter [his region out of the project]." (Academic #1)*

Knowledge mobilization to advance conservation, sustainability and social benefits is retarded when not all regional partners are willing to engage in the process. The BHB and its predecessor, the BHI, struggle, like all biosphere reserves, to cultivate and secure partner engagement on a long-term basis.

3.4. Knowledge Mobilization and Decision Making Is Layered and Complex

Participants described a complex and dynamic system of knowledge creation and use. Many decisions that are made for parks and conservation management were described as reactionary or based on previous experiences, therefore creating layers to the use of various forms of knowledge. Even when the BHB consciously plans to use knowledge to inform their planning and facilitation efforts there are a host of factors that affect their ability to do so. These include such things as time, finances, and training required to "do" science, fears of what research will find and how to apply and communicate those findings, various government and bureaucratic policies, and challenges associated with collaborations and partnerships.

Time is one of the most frequent barriers; time to lobby organizations and governments to invest in a knowledge creation project, time to circulate new knowledge to co-workers and superiors, time to

engage the public in meaningful outreach were frequently cited time scarcity examples provided by study participants. Participants felt pressure to react to problems or management decisions rather than prepare and conduct future planning and relevant research:

"Yeah, because you know you are dealing with the day-to-day, which is the problem you do some research, but you don't always have the time to get the data sorted, so you need to find some students or something and look around at different sources. It's the name of the game you see the problem, try to put out the fire and then try to put the research knowledge out there so you have it for the future and a better understanding of the problems and issues. You are reacting big time." (Park Agency #6).

Efforts to promote new ideas within regional organizations, which takes time but also influence and ability to push information "up-" and "down-stream" in an organization is reflected in this comment: *"The real difficulty I think, and this applies not just to the government only, but also to NGOs and so forth, is how do you get that information back up the line to make the people who basically decide policy and allocate resources that is the important issue." (Academic #2)*

Biospheres are areas where people live and work close to and within a natural landscape, which poses unique questions and management strategies that require pooled knowledge and expertise. However, fear appears to be holding the BHB back from realizing some of the potentials of their partnerships and pooled expertise. While some are afraid of admitting a mistake and thus not allowing others and themselves to learn from that mistake, others are afraid of not having the expertise required to engage in research. Instead of relying on partners within the BHB (i.e., academic or NGO institutions with specific research skills) they simply avoid certain opportunities: *"so it's that kind of thing about improving business and admitting we made a mistake and to learn from it but there's this, whoa we can't admit fault, error, we can't talk to people." (Park Agency #1).* A second quotation supports this issue:

"So I think having a go back to our comfort level of you know if we see X species that we know it's there that is something we can be sure about whereas if you have to disseminate that information socially for the social sciences in a way that is effective and also representative I think it's something that I struggle with. How do we know that we're talking to the right people or have a good representation of the data from the area and it's not just the opinion of one person that may or may not be accurate." (NGO #5)

A biosphere reserve also poses a unique challenge in regards to knowledge creation, as they often encompass peri-urban areas and developed lived-in landscapes. This urbanization and development are accompanied by layers of government, and biosphere reserves must continually adapt to municipal, provincial and federal election cycles and competing political agendas. This timing creates additional pressure for BHB agencies and partners to react, and hinders their ability to conduct in-depth or longitudinal research projects: *"Yeah it completely forces us into short term projects." (Park Agency #5). "Council only has four years and they need to make their mark in that short amount of time. Research, we know goes year and years and that's the trick with municipal government and decision making, you may have a decision for four years." (Municipality #2)*

Capacity and training appear to be lacking in certain areas; however, it is unclear why the BHB and its partnership is not being called upon in more significant ways to address the capacity gaps between one organization and another. Specifically, an interest in but lack of capacity to conduct social science research, access and understand social science findings, and engaging with local and Indigenous knowledge is articulated well in these quotations:

"The challenge right now is to demonstrate enough capacity to the leadership that they'll trust in me that I'm taking them on a path forward right, because no disrespect to the past but the path might not have been as straight as we needed it to be. So, I think about it now as how can we [accomplish this] as a biosphere, the evaluation of effort of the social science effort. So, we talk about the extension of programming if I had tools and resources that could demonstrate the effectives than that would resonate with partners even more so." (NGO #1)

"Probably more resources or more a better understanding amongst the rest of us that don't do it typically about how that could be utilized or how that would feedback to the work that we do. So um with the Friends [of Elk Island National Park] for instance if I could figure out what drives people to go out in the park or to get involved in citizen science or to want to learn about those kinds of things. In fact, that kind of information

would be useful for us in terms of shaping our programs for our offering so that we could engage more people." (NGO #3)

Similar sentiments relating to capacity and training were noted for engaging with Canada's Indigenous peoples and the knowledge exchange and co-creation that would arise from that effort.

In short, the knowledge created, used, and mobilized within the BHB is a representation of the efforts of many years of dedicated and passionate individuals and agencies. However, long-entrenched traditions of how "things are done", limitations in terms of time, capacity and finances, and complexities of the landscape and actors involved (i.e., political process, relations, influence, trust and control) have shaped decision making throughout the biosphere's lifespan and may continue to do so.

4. Discussion

Study interviewees struggled to provide specific examples of knowledge used for the biosphere reserve application or ongoing landscape management collaboration efforts that were sourced outside of traditional natural science fields of study. Park visitor statistics, information gathered at public consultation campaigns, and economic impact studies were consistently and solely identified as 'social science,' when interviewees were pressed to provide non-natural science examples of knowledge that could be used for management and planning within the BHB or that had been used to support the BHB's application for biosphere reserve status. This trend corroborates findings from other studies [21,22,31] that highlight the need for more social science research and application of its findings in biodiversity and environmental management efforts. Two examples of this include Head's [60] study of the use of human dimensions research in addressing invasive species and Harris, McGee, and McFarlane's [61] examination of local municipalities' emergency preparedness for wildfire, including the use of social science. Invasive species and wildfires are two challenges that are increasingly prevalent for the peri-urban context of the BHB. Wildfire has long been of interest to the BHB and generated substantial research and management action, based entirely in natural sciences (fire history and risk prediction). Such studies do not readily translate to management action though, and as some participants noted, this information has not been embraced by partner agencies as quickly as expected. In other regions, social aspects of management such as perception of risk have been well studied, and used to communicate risk in community education and awareness programming, e.g., [62]. A broader understanding of the applications and benefits of social science would be helpful to the BHB, and other similar initiatives.

When asked about the potential of Indigenous knowledge, traditional ecological knowledge or local, land-based knowledge for achieving BHB management objectives, replies were more apologetic in tone or interviewees had no examples to share. Engagement with the diverse Indigenous peoples who have historic and cultural ties to the Beaver Hills region has been limited, and, as articulated in the Findings section, led to, in addition to lack of public outreach in general, the failure of the first application for biosphere reserve status. This lack of engagement with 'others' and alternative ways of knowing is not uncommon. Lemieux et al. [63] in a survey of 121 Canadian conservation professionals found that while traditional (including local and Indigenous) knowledge was valued to a moderate degree (i.e., 2.9 out of 4, where 1=Not valued at all and 4=Very Valuable)), it was used much less often, scoring 2.2 out of 4 on a similarly framed "Use" scale. Lemieux and colleagues also noted that Indigenous knowledge was significantly less valued by professionals who were male or had longer professional service records. Calls for Indigenous knowledge, characterized by some researchers as traditional ecological knowledge have been made for at least two decades now [15–17], however the shift to embrace this knowledge as an equally valued tool for supporting conservation and sustainability objectives has been slow. Based on findings from a study of the potential for traditional and local ecological knowledge to contribute to biodiversity conservation in the US Pacific Northwest Coast, Charnley et al. [19] suggest knowledge holders must be directly engaged as active participants in conservation efforts. However, social, economic and policy constraints must be addressed to facilitate this involvement. In Canada, the capacity of Indigenous governments and communities to collaborate

is oversubscribed at present—this is a real constraint of which the BHB is mindful. The BHB also recognized the need for its network partners to increase their capacities to engage with Indigenous actors. Efforts to promote cross-cultural awareness and communications challenges, adoption of a more holistic socio-ecological systems thinking, and identification of common goals are a few of the overarching recommendations for addressing the pluralistic and dynamic perspectives that characterize the efforts to manage large scale landscapes [64–67].

Unexpectedly, very few of the focus group participants cited examples of local knowledge being employed to advance the development of the BHB, its application package, or its current collaborative activities. Undoubtedly, within a wide-ranging landscape such as the Beaver Hills, the agencies and partners involved in the BHB collect and utilize local knowledge in their daily and annual efforts (e.g., in land use planning), but these forms of knowledge failed to surface as common sources of information amongst interviewees. In comparison, appreciation of and use of local knowledge in Lemieux et al.'s [63] survey of Canadian conservation professionals, identified patterns of valuation (3.2 out of 4) and use (2.6 out of 4) of local knowledge for the evidence-based management of Canada's protected areas; this was slightly higher than scores relating to Indigenous knowledge from the same survey. The study also documented experiential expertise of managers was more valued and frequently used by conservation practitioners. The subordinate role that lay or local knowledge plays in comparison to technical or scientific knowledge has been documented in other contexts, including van Tol Smit, de Loë, and Plumber's [68] examination of collaborative environmental governance in New Brunswick, Canada, and may explain why, even when prompted, local knowledge was rarely discussed as a source of knowledge from decision making by BHB actors during our focus groups. Hockings et al. [3] call for greater integration of science and local knowledge to strengthen biosphere reserves, suggesting they are excellent laboratories for testing integration of scientific, local and Indigenous forms of knowledge. Raymond et al.'s [6] comparison of three projects that attempted integration of local knowledge into environmental management efforts noted there is no single optimum approach for integrating local and scientific knowledge and observed the need for future efforts to be systemic, reflexive and cyclic.

Study participants noted the partnerships and network afforded by the BHB and its establishing board, the BHI, were invaluable for improving their access to knowledge. Study participants suggested knowledge was created and exchanged more often between organizations because of their involvement in the BHB. The BHB and its predecessor, the BHI, could be labelled as a boundary organization, bridging the divide between knowledge creators and keepers, and knowledge users [69]. Boundary organizations, often NGOs, have traditionally bridged the gap between science organization and knowledge users [69]. The BHB, on a monthly basis at its board and advisory committee meetings, through its newsletters and related communications tools, and via initiatives such as the biosphere reserve application process or FireSmart preparations facilitate communications and knowledge exchange [2]. However, the BHB and its predecessor the BHI, have tread a fine line, working to maintain neutrality and autonomy, and not appearing to align with one partner agency vs another. The perceived influence of one of its main funders, the largest of five municipal partners, has at times, slowed the buy-in of other neighbouring municipalities. This was exemplified in the FireSmart program and a municipality's refusal to get involved, gaining access to and exchange information that would have helped it prepare for wildfires. To be a successful boundary organization, the BHB must strive to represent all sides in efforts to facilitate the exchange of information between knowledge users and producers, maintaining its independence. As an example, finding ways to better solicit and integrate local knowledge, would help to remove perceptions of bias. Similarly, working with Indigenous partners to explore areas of potential collaboration, in ways respectful of capacity constraints, and the need to develop shared cultural understandings would help to build trust, an essential starting point.

Study participants also claimed their participation in the BHB, as board members or advisers, improved their ability to bring knowledge from other organizations into their own agencies, but also move information within their agencies more effectively. BHB leadership (i.e., board members

and advisory committee members) appear to be performing knowledge brokering within their respective agencies, especially when it comes to the sharing and curation of Beaver Hills environmental data. Knowledge brokers facilitate the exchange of knowledge among policy makers, practitioners, and knowledge creators and keepers [2]. Amongst study participants, numerous examples of sharing and generating natural systems knowledge was alluded to, however, while the importance of acquiring and applying cultural and social knowledge was acknowledged, many of the participants interviewed noted the lack of training and easy access to this knowledge.

Co-creation of knowledge that advances biosphere reserve objectives such as sustainability, biodiversity conservation, cultural heritage conservation and social benefits also needs to be adopted by the BHB and regional actors. Our understanding of co-creation of knowledge is that it entails people exchanging perceptions of a particular phenomena and collaborating to learn more about that phenomena together. The objective of these efforts is the co-creation of knowledge, which will inform action, leading to biosphere reserve-relevant goals such as social, cultural and environmental benefits [70]. A few focus group participants noted partnerships between agencies and individual staff were productive in advancing a shared understanding of a complex problem, such as ungulate management (i.e., moose (*Alces alces)* and elk (*Cervus canadensis*)) in the Beaver Hills. They also mentioned citizen science activities, whereby residents and visitors helped to collect data, particularly in the region. It was unclear if the latter project was co-creation or co-production of knowledge.

We acknowledge the terms co-creation and co-production are often used interchangeably by some environment and knowledge mobilization experts, i.e., [2,71,72]. However, we understand co-production of knowledge to be an activity that does not include all actors in the planning process (e.g., debating what data collection method to use or what research question is most salient). Despite these subtleties in definition, the intent is the same—knowledge mobilization for conservation through collaboration. The importance and efficacy of co-creation and co-production processes were documented by Nel et al. [71] in their study of a 4-year conservation planning project in South Africa. They found that knowledge co-creation stimulated dialogue and negotiation and built capacity for multi-scale implementation beyond the original project—in short, it led to conservation action. Though not explicitly carried out as a co-creation project, the effort to document and share information (primarily about biological resources) between BHB conservation and land management agencies, with an aim to enhance landscape management and the creation of the biosphere reserve, shared many of the characteristics of the study detailed by Nel et al. [71]. However, diversity of voices (i.e., the public at large, Indigenous communities) and subject matter (e.g., social, cultural, economic) were less richly debated and documented during the BHI's efforts to obtain biosphere reserve status for the region. The effort appears to have been more focused on finding common cause, and support to drive the biosphere reserve forward toward designation. Acknowledging differences then may have defeated the main goal of designation.

Study participants unanimously agreed the BHB, and its predecessor the BHI were effective catalysts and facilitators of knowledge mobilization in the Beaver Hills region. However, knowledge mobilization collaborations were not always easily formed, needed time to develop, and key organizations were not consistently involved due to political and economic forces or the pull and push of power personalities. As a result, knowledge mobilization efforts have been stymied at times. As noted earlier, focus group participants noted that some potential partners were difficult to bring to the collaboration because of a fear of losing control. They did not want to support a biosphere reserve that could, in their minds, add another decision-making organization to the region with whom they would have to negotiate. Over time, with the right mix of personalities, the patient building of trust, and the recognition of common goals and values were used to reinforce nascent relationships and the forging of new partnerships. The development of strong personal relationships has been observed as an essential ingredient in successful partnerships [73]. Trust emerges from these personal relationships as does social capital. In her study of the factors that lead to the success of the BHI, Patriquin [45] observed these phenomena were essential ingredients to its success. She also observed that trust was

built more often between people than agencies, which corroborates our speculation that the bonds that bind the BHB and facilitate its success as a knowledge mobilization organization, are driven more by individuals than agencies.

Stronger personal relationships bring higher levels of social capital, which can be utilized for more effective problem-solving and result in an expectation of reciprocity, resulting in long-term obligations between people [74]. Brown [75] suggests this can help bridge the gaps created by different levels of power and knowledge [73]. Patriquin [45] observed in her study of the BHI that trust and social capital were essential in advancing new knowledge and evidence-based management initiatives. These included data sharing, funding raising, and effort to seek biosphere reserve allocation. Shared cultural understandings, specifically a long-term history of conservation value of the moraine, also played a role. The value of the natural environment was a rallying factor for the nomination, more so than its cultural history, a factor that may contribute to the challenges in engaging local and Indigenous understandings in the BHB's management initiatives.

Gavin et al. [64] note that conservation is often called a crisis discipline, as much of its research output is focused on declining species and landscapes, and ineffectual debates about the best path forward to address these declines. Crisis is often used as a springboard inspire action, but actors are not certain if it is the right action at the right time. This sentiment was articulated by many of the BHB focus group participants who lamented that much of their work was reactive, lacking long term resourcing or leadership support. Many of their projects were short term due to political electoral cycles and related ability to access funding and permissions to engage in data collection or evidence-based policy and management recommendations. Efforts to engage in long-term knowledge creation and curation is perceived as a central challenge to the BHB and similar collaborative efforts. Straka et al.'s [66] study of muskrat populations in Canada's Peace-Athabasca Delta, illustrates the efficacy of long-term ecological monitoring that includes partners such as Indigenous communities.

To facilitate these collaborations, constraints and deficiencies such as time and financial resources, as well as the capacity of individuals (i.e., conflict resolution, cultural awareness and appreciation of diverse world views and disciplinary approaches) and organizations need to be addressed. The environmental management knowledge mobilization literature provides insights on how to address some of these challenges (see [37,47,64,66] for examples).

5. Conclusions

5.1. Study Limitations

The story of Indigenous knowledge mobilization as it relates to the formation of the BHB and its ongoing administration, governance, and collaborative activities is not fully understood from the interviews conducted for this study, as Indigenous representatives did not participate in the focus groups. However, focus group participants who work closely with different Indigenous communities who have historic and cultural ties with the Beaver Hills, did reflect on some of the challenges and opportunities relating to Indigenous knowledge mobilization. We also did not ask interviewees about their use and valuation of professional knowledge or the experiential knowledge accumulated and employed by managers [3,8,76]. Probing for information about this type of knowledge from practitioner participants may have contributed a more fulsome and realistic understanding of management and planning decision making in the BHB, and should be included as a focus in related studies.

Our sample size could be critiqued as being small, given the scale of the Beaver Hills region, and number of BHB partners and organization staff involved. However, our desire to assess knowledge mobilization over the timeframe leading to designation of the BHB, from the perspective of its various partner organizations, constrained selection of potential participants. Most current BHB leadership (i.e., board and advisory committee members who work for government, academic, and NGOs) were interviewed, as well as a number of previous participants who also served with the BHI. Finally, we suspect the longitudinal focus of our study made it difficult for participants to name and describe

their perceptions of knowledge and knowledge use over such a long-time frame; the study could have benefited from a narrowed temporal focus.

5.2. Future Research

In addition to social science, the contributions of humanities and the arts research traditions to advancing the effective management of protected areas and landscapes such as biosphere reserves should be explored. These disciplines can also be used to critique and suggest alternative ways forward to advancing conservation and sustainability [77]. The arts and humanities articulate and inspire diverse ways of knowing in unique and challenging ways, often helping regional actors reflect on relationships with nature and each other. In the near future, examining the efficacy of the application of the arts in the BHB, in knowledge translation and negotiation may prove to be a fruitful avenue for the BHB to engage new constituencies with. As an example, profiles of the current and past residents of the moraine, in a manner similar to that used to document its natural heritage, could help build connections with local and Indigenous communities, and engagement with the BHB.

To engage in knowledge mobilization relating to Indigenous knowledge, deeper relationships are needed with individual Indigenous persons, groups, and governments. Relationship building will develop trust and advance reconciliation efforts, which are ongoing throughout Canada. Understanding of epistemological perspectives and ethical protocols will be needed to pursue joint research initiatives, but firstly, a deeper understanding of the colonial history that has influenced Indigenous connections to this landscape is needed to facilitate reconciliation and then encourage partnerships. This process will need to include skills and knowledge development of BHB leadership and staff within the biosphere reserve, but also key partners of the reserve. This is already occurring at protected areas located in the BHB such as Elk Island National Park, Cooking Lake Blackfoot Provincial Recreation Area, and Strathcona Wilderness Area. These parks are co-creating programs and policies with Indigenous communities. Research activities must involve "more collaborative and empowering forms of participation, and the use of Indigenous epistemologies and methods" [78,79]. This effort will have to be facilitated by the increased capacity of Indigenous communities to co-create and co-produce knowledge (e.g., financial and technical assistance, Indigenous controlled research infrastructure) and respectful dialogue to gauge interest in such activities. Traditional institutions (e.g., universities and their funders) must also recognize the complexities of ethics and financing that are needed to develop research relationships, co-production of knowledge, and secure knowledge asset management [67,79].

Our focus group interviews did not allow us to delve deeply into past and potential BHB co-creation and co-production of knowledge activities. Noting Cvitanovic et al.'s [2], Onaindia et al.'s [70] and other's [78,80] identification of the potential for these approaches to engage regional actors, build relationships and produce knowledge that is more supportive of biosphere reserve goals, we recommend a more expanded inquiry into how knowledge co-creation and co-production occurs in complex lived-in landscapes such as the Beaver Hills. Follow up studies of citizen science, public history curation, and wildlife preparedness planning are topics the BHB is pursuing that may provide further lessons that will enhance knowledge mobilization efficacy and efficiencies.

5.3. Concluding Thoughts

Returning to our original objectives, we asked how park, conservation, and other land management agencies associated with the BHB are able to access knowledge when making management decisions. In short, access depends on the type of knowledge, level of collaboration, and potential for application. In addition, we asked how the BHB allows for the ongoing use of knowledge mobilization amongst partners. Similarly, effective knowledge mobilization requires patience, long-term collaboration, equality among partners (perception and reality), and an appreciation of how complex knowledge really is.

As the BHB moves into its first decade of operating as a biosphere reserve, building on an additional decade of foundation building by the BHI, the organization and partnership must be

mindful of several challenges. This is particularly salient for addressing calls by international experts who suggest biosphere reserve success will be contingent upon efforts to "engage with and support diverse knowledge holders and knowledge systems" [81]. First, the diversity of knowledge sources is important, namely a broader incorporation of social science, humanities, and arts generated disciplinary outputs are essential to advancing sustainability and related biosphere reserve goals. Equally important in achieving these goals will be Indigenous engagement and knowledge exchange, as well as partnerships and information sharing with local communities, landowners, and traditional users. The BHB is taking steps toward this through applied research projects in partnership with local universities. One example of this is a humanities-informed project in which historians are interviewing local residents and collecting archival materials for a public history project [82] to deepen and empower public connection with the BH's past. Additional capacity development within the BHB, with respect to Indigenous history and culture will be necessary to ensure respectful, and equitable collaboration.

Second, as the BHB formalizes its governance, stabilizes its revenues, expands staffing, and establishes strategic priorities, it must work hard to maintain a commitment to being an "open system —philosophically and operationally" [83] ensuring access to diverse perspectives, skills, and resources of individuals and organizations. Through interviews with leaders associated with the Yellowstone to Yukon (Y2Y) initiative, Mattson et al. [83] noted that as large-scale conservation organizations mature, consolidation of power around a long-standing formula reduced the effectiveness of Y2Y. As a biosphere reserve, and based on the BHI's previous successes of partnership building, this openness and dialogue must be maintained (this has been the case with most conservation agencies and municipalities) and expanded to other groups such as the public at large and specific actors (e.g., Indigenous governments and individuals, landowners, recreation users, and industry). These efforts will build trust and exchange of ideas, and relatedly for this article, the mobilization of knowledge that can be used to advance the broad array of park management objectives including biodiversity and cultural heritage conservation, and social benefits. To foster successful governance of the BHB and biosphere reserves like it, Vasser [84] recommends the pace of governance and management must consider "spatial and temporal scales of ecological processes within a socio-ecological system" (p. 309) and in particular consider different cultures' approaches to time, process and procedures. He cites Canada's Indigenous Circle of Experts (ICE) process to generate recommendations to achieve Canada's commitment to its Aichi Target 1 biodiversity protection goals, as one example [85].

Third, partners and especially leadership within the BHB must work hard to be conscious of the inherent economic and discursive power that coalitions within the Beaver Hills wield in the prioritization of biosphere reserve activities, based on narratives that are exchanged and promoted. These narratives are rooted both in local experience and knowledge as well as scientific data and the professional 'know-how' and influence of politicians and practitioners. One of the most contentious challenges of the region, the management of beaver populations, especially during years with high levels of precipitation, shares many parallels with observations made by Robbins [86] in his review of ecological knowledge relating to wildlife management and ranching in Northern Yellowstone and Maderson and Wynn-Jones' [87] examination of beekeepers' knowledge and participation in pollinator conservation and tensions with agricultural production. In short, efforts to listen to silent and silenced constituencies need to be a long-term commitment of the BHB as it moves towards its biosphere reserve objectives.

Finally, we would like to acknowledge that Canada has a history of land management that devalues community integration and consultation and rather imposes parks based on ecological and conservation science [88–90]. As such, in this paper, we assert that social science research, characterized by distinct disciplinary theories and methods but focused on advancing social knowledge, has not received the same recognition as natural science within North America and Western conservation contexts [21]. Globally, there may be different understandings of and valuations of social science as a practice; within the BHB, understandings of what social science is and what it may contribute to conservation management is still very much at an early stage of development. We believe that all

forms of knowledge are essential to effective conservation and land management and therefore are advocating for interdisciplinary approaches in park and land management.

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Appendix A

Research Interview Questions

Opening Section (Participant Background)

1. Could you please describe your professional background (eg. education, job experience) relative to [case study location]?
2. How has knowledge (and what kind of knowledge) has typically been integrated in planning and management for the Beaver Hills Biosphere [and/or its predecessor, the Beaver Hills Initiative]? Note: some time period may be useful (e.g., over the past 2 to 5 years)?
3. Can you describe your professional role in conservation/environmental management in the Beaver Hills Biosphere [and/or its predecessor, the Beaver Hills Initiative]? What are the key management issues that you have been involved in recently? How well has your background educational or work background prepared you for that role?

Knowledge Mobilization Section

Case-specific Management Decision-making Processes:

1. Can you describe (one to three) important management decisions that you helped make will working within the Beaver Hills Biosphere [and/or its predecessor, the Beaver Hills Initiative]?
    a. For each decision, would you please describe how the decision was made (open ended start to discussion)?
    b. Now would you outline what kinds of information were used to assist in making each decision (probe for possible types of information, e.g., colleagues, government documents)?
2. Can you describe a decision where **social science** (e.g., psychology, sociology, political science) was used to help with the decision making relative to each management issue (may need to probe to explain what is meant by social science)? Why was social science integrated into management of this particular issue?
    a. Can you describe any difficulties or barriers in accessing or applying appropriate social science information in making decisions such as this, at this case study location? (Relate this back to theoretical context, and known barriers/enabling factors.)
3. Can you describe a decision where **natural science** was used to help with decision making (may need to probe to explain what is meant by natural science)? Why was natural science integrated into management of this particular issue? Was it easier to incorporate natural science, relative to social science in this example situation?

   a. Can you describe any difficulties or barriers in accessing appropriate natural science information in making decisions? Any enabling conditions that helped access scientific information useful for decision-making? (Relate this back to theoretical context, and known barriers/enabling factors.)

4. Can you describe a situation where **traditional ecological knowledge, Indigenous knowledge, or other forms of local knowledge** were used to help making a decision (may need to probe to explain what is meant by traditional ecological knowledge or local knowledge.)

   a. Can you describe any difficulties or barriers in accessing appropriate traditional ecological knowledge, Indigenous knowledge or other forms of local knowledge in making decisions? Any enabling conditions that helped access scientific information useful for decision-making? (Relate this back to theoretical context, and known barriers/enabling factors.)

General Process of Knowledge Application:

1. Do you think some forms of knowledge can be integrated into biosphere-related planning and management easier than others? Why do you think that?
2. What do you think are/were the main opportunities and barriers to integrating scientific knowledge into biosphere/BHI planning and management? Do you think these barriers could be minimized in any way?
3. What do you think are/were the main barriers and opportunities are for integrating Indigenous knowledge into biosphere/BHI planning and management? Do you think these barriers could be minimized in any way?
4. Many researchers suggest that conservation decisions have traditionally used primarily natural sciences to help them plan and manage protected areas/ecosystems/landscapes.

   a. Would you agree with this assessment, and why or why not?
   b. What would it take for either social science or Indigenous knowledge to be more fully integrated into Beaver Hills Biosphere planning and management?

5. What kind of knowledge is typically used to deal with any social science-related issues in the Beaver Hills Biosphere (e.g., overuse issues or problems dealing with recreational conflicts between users)?
6. What trends do you see in accessing and using various types of knowledge in management and planning decisions in the Beaver Hills Biosphere?

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