

Effective Incorporation of Indigenous Knowledge into Biological Field Stations/Place-based
Research Institutes

By:

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Abstract

Indigenous Knowledge (IK) has emerged as a valued source of information for many non-indigenous researchers and practitioners. Until recently, the use of IK has been sparse and, in many cases, used with little respect, and the individuals who hold it tended to be excluded from credit. This fact, among others, has created barriers to collaboration between the scientific community and that of Indigenous peoples. In this study I explore the use of IK and its incorporation into biological field stations and place-based research institutes. Specifically, I examine how integration of IK and western science (e.g. landscape ecology (LE)) is applied to research and management. I carried out a focussed literature review on the subject to develop criteria and themes on the use of IK in research and management. These criteria were used to assess the five case studies (Georgian Bay Biosphere Reserve, Queens University Biological Station, Haida Gwaii Institute, Turtle Island Conservation, and River Institute). The cases provide insight into relevant practices that are being used to efficiently and ethically incorporate IK into research and management. An understanding of how IK can be integrated with science through field station and place-based research Institute activities was developed based on these cases. This will allow other benefits to arise such as the further incorporation of IK into research projects as well as other unexplored fields including engineering and computer science.

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niá:wen kòwa – thank you

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Abbreviations

IK – Indigenous Knowledge

LE – landscape Ecology

TA – Thematic Analysis

DA – Document Analysis

Introduction

Rotehrákwas yónkats tánon wakhskaré:wake - My name is Rotehrákwas and I am Bear Clan. I am from Tyendinaga Mohawk Territory and spent my life on the territory until moving to Kingston for university. I was raised with Indigenous values and history as the foundation of my education. This provides me with a holistic view of environmental biology that has since been supplemented with western science. My unique understanding of “integrated/co-produced” Indigenous and western science knowledge along with conversations with community members contributed to the development and analysis of this thesis.

IK is generally insufficiently integrated into field station/place-based research institute operations including related to research and management (Gorelick, 2014). An overarching reason for this is the current lack of understanding of the value and potential IK has to contribute to academic research and the generation of co-produced/integrated knowledge (Schmidt & Stricker, 2010). Often referred to as “traditional ecological knowledge,” “folk knowledge,” or “non-formal knowledge” among other names, IK is mistakenly considered ambiguous and its complexity and depth misunderstood by many (Maragia, 2006; Gorelick, 2014). Indigenous knowledge can be accurately described as systematic, observational, adaptable, and dynamic but also conditional and applicable to a particular spatial geography (Battiste, 2005; Maragia, 2006).

Understanding IK for these unique qualities, this knowledge base may be further accepted as ‘scientific’ and applied in a wider setting. In the past few decades the qualities of IK have been increasingly recognized as relevant and valid and science has slowly started to change towards a collaborative approach, in some cases working alongside Indigenous knowledge holders in research and to address environmental management (Battiste, 2005). Maintaining a high level of collaboration has not been without challenges.

Barriers from both knowledge domains have limited the full incorporation and co-production/integration of IK and western scientific knowledge, notably issues of research documentation and intellectual property (Battiste, 2005; Maragia, 2006). Indigenous cultures are largely based on oral teaching and holistic mentalities. This extends to approaches taken in conducting research and recording findings. Indigenous research is done in an observational fashion that considers more complex system interactions that western science tends to exclude. Along with this, novel discoveries and new insights are maintained orally and passed down through generations in stories and legends. In contrast, western practices tend to be objective and only considered academic if certain methodologies have been followed and published in accredited, peer-reviewed journals (Aikenhead, 2001). These differing views present barriers and challenges to the integration and collaboration of Indigenous and western approaches.

Considering the strengths and shortcomings of both Indigenous and western views, my thesis analyzed current best practices within field station/place-based research institutes and organizations that highlight the potential of co-production/integration of knowledge with emphasis on collaboration.

There are overlaps between IK and different fields of western science; however, each field overlaps slightly differently (Gorelick, 2014). Because of this I focus mainly on the overlaps and

possibilities of co-production of knowledge/integration with IK and Landscape Ecology (LE) through research and management collaboration. Indigenous knowledge and western science have been defined using an array of qualities and definitions. Battiste (2005) describes IK as being based on skills and abilities for problem solving that changes with the environment. This application based environmental knowledge has commonalities with the discipline of LE. LE is the study of ecological factors that underlie spatial patterns found in an ecosystem (Turner, 1989). The way IK and LE potentially complement each other underpin my research for how they can lead to co-produced/integrated knowledge in the field station/place-based research institute context (Michener *et al.*, 2009).

The objective of my thesis is two-fold. The first builds the platform upon which the second is based.

1. Understand how IK is used by field stations and place-based research institutes, and how it is or is not being integrated with western science
2. Identify strengths, weakness and best practices of IK and science integration to inform how IK best fits into the work of field stations/place-based research institutes.

These objectives guided my thesis throughout the literature review, data collection, and the final analysis and report.

Literature Review

Indigenous knowledge (IK) overlaps with western science through many disciplines such as astronomy, physics, and biology (Drew & Henne 2006; Gorelick, 2014). I will focus on the relations between IK and biology, and more specifically LE and similar subdisciplines that are often applied in biological field station/place-based research institute activities. To understand the relations and how they can be managed for efficient co-production/integration of science and IK knowledge, this literature review doubles as the first part of the analysis process, detailing

three topics that must be understood to facilitate proper integration. Indigenous knowledge, landscape ecology, and field station/place-based research institute mandates and operations must first be described. The definitions and overlaps will then be used to break down current literature to compile a list of the barriers that have prevented and continue to limit the integration of IK and western science. I then use these barriers to build the criteria or conditions that current and future field stations/place-based research institutes can use to guide productive collaborations and co-production of knowledge. Criteria determined through this literature review further guided the evaluation of the cases (see methods section 3).

Definitions

Indigenous knowledge is described in many ways and with various names. Most often referred to as traditional ecological knowledge (TEK) in research papers (Rai, 2007; Drew & Henne, 2010), but also as Indigenous science (Gorelick, 2014), folklore, local knowledge, traditional biocultural consideration/knowledge (Margaria, 2006), fuzzy knowledge (Gorelick, 2014), local wisdom, culture, non-formal knowledge (Battiste, 2005) and Indigenous knowledge. In this paper I use the term IK. Many of these names tend to ignore or miss the complexity and diversity found within the information from IK. Riggs (2004) captures this complexity quite well in his definition of IK, referring to it as “composed of three separate and independent types of knowledge, namely empirical knowledge, paradigmatic knowledge, and institutional knowledge”. Empirical knowledge is often referred to as sense knowledge as it is that which is observationally or experimentally gained from direct interactions and experience working with natural systems. Paradigmatic knowledge is where IK differs from modern science. This is knowledge related to the relationship Indigenous people have with nature such as the “interpretation and cultural construction of causal relationships, interrelations, and the meaning

of these relationships within the empirical knowledge held within an indigenous knowledge system” (Riggs, 2004). This aspect is most important when considering the integration of IK and science as it is the greatest barrier. I will elaborate later. Institutional knowledge is defined as how the two prior knowledges are used in people’s daily lives and incorporated in their behaviors – institutional knowledge forms people’s environmental, social, cultural, and economic relationships (Riggs, 2004). However, much broader and simple definitions are accurate as well, such as Battiste (2005) definition: “Indigenous knowledge is an adaptable, dynamic system based on skills, abilities, and problem-solving techniques that change over time depending on environmental conditions”.

Landscape ecology, unlike many other biological disciplines, takes a more holistic approach to scientific inquiry seeking to understand patterns in the environment (Turner, 1989). Research in this area is often done by analyzing broad spatial and temporal scales allowing an understanding of the complex interactions seen between geographic and ecological processes that shape ecosystem heterogeneity (Turner, 1989; Wu, 2001). This broad holistic view is similar to that of IK, yet LE is broadly used and integrated in research and management, whereas IK is not. Potential use and integration of IK with LE becomes clear when seeking to understand both fields and outlining where they overlap as well as where they diverge. Scientific inquiry has often benefitted from interdisciplinary collaboration especially between fields with quite different views such as landscape ecology and population genetics, i.e. landscape genetics (Manel, 2003). With a recognition of the similarities between LE and IK, the approaches to incorporate IK should be similar to other interdisciplinary work with LE with a few exceptions (described as barriers below). Both LE and IK work with large temporal datasets and complex ecosystems. Biological field stations/place-based research institutes are known for housing these

types of datasets (Michener *et al.*, 2009), which is why I consider these types of organizations as having potential for co-production/integration of knowledge to occur.

Landscape ecology is often conducted at biological field stations/place-based research institutes but also through other organizations such as biosphere reserves and wildlife centers (Francis, 2004). These organizations tend to slightly stray from the stereotypical science approach by striving to achieve cultural and socio-economic benefits for local peoples in addition to their ecological and technological considerations (Francis, 2004). I will refer to all such entities as field stations/place-based research organizations. Field stations/place-based research organizations tend to focus on local/regional scales such as the biome where they are situated, similar to that of an individual/community of Indigenous knowledge holders (Gorelick, 2014). These local/regional data are usually shared with other networks (field stations, biosphere reserves) allowing the scale to enlarge to inform broader regional and global monitoring and research projects (Tydecks, 2016). This aligns with the practices of IK that no two people hold the same knowledge and only as a network of individuals is the full story understood (Bartlett, Marshall, & Marshall, 2012). Knowing the relationship between these scales as well as management practices at individual stations/place-based research organizations will potentially increase the comprehensiveness of the role IK may play in the system of concern.

Barriers

Through text analysis (TA; see methods section for explanation) I was able to break down the literature I selected for the review into groups of common ideas. This provided me with a list of the perceived barriers to IK integration grouped together from all of the analyzed articles. The barriers category consisted of 118 separate codes which was the most in any category and 28 codes more than the next highest code group: 'criteria' (Figure 1). Criteria are

common concepts across the literature that should be focused on to promote an efficient and respectful collaboration with IK.

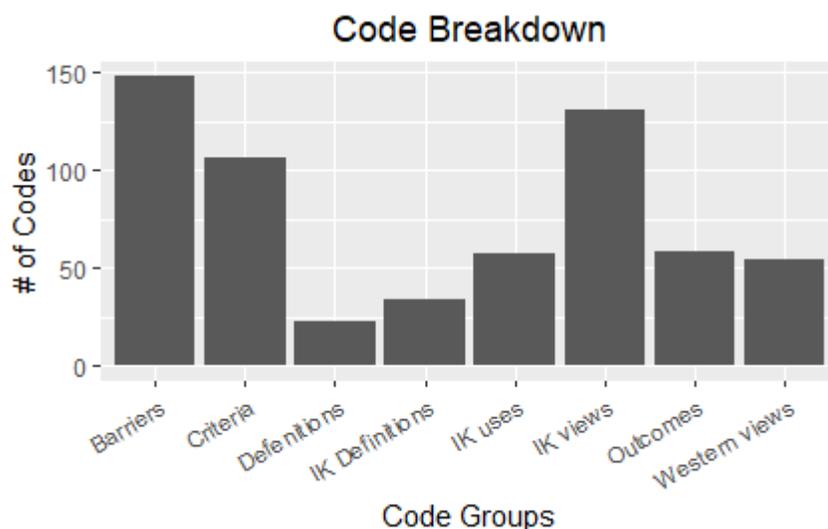


Figure 1. Document analysis of literature review outlining common barriers and criteria used to develop cases. Bars show the number of codes gathered for each category/code group across the literature.

From the sheer number of codes, it is easy to deduce that barriers (as in barrier to integrate) are the most studied topic when it comes to the use of IK. Nonetheless, I also broke down the common barriers to give context to the criteria needed to overcome the barriers identified. There were five main barriers found, each with overlap - language, governance, mode of research, and historical conflicts. Each of these is described below.

Culture

Modern science has often considered culture a topic to avoid in research whereas IK keeps culture as a top priority in all aspects of its utility (Schmidt & Stricker, 2010; Kimmerer, 2013). Avoiding culture is impossible as it is what defines us as a person and what we believe to be true (Clarkson, 1992). Science itself is a culture, a way of understanding and finding truth. IK

is the same as it also aims to understand and find the truth but simply does it through different techniques (Bartlett, Marshall, & Marshall, 2012). Indigenous knowledge holders view nature and its queries in a personal way that actually benefits from considering one's culture (Snively & Williams, 2016). Bartlett, Marshall, & Marshall (2012) explain that there are four levels or "circles" of knowledge: physical knowledge, personal connection with the knowledge, respect for the knowledge, and sacred nature of the knowledge. The latter three circles do not fit with contemporary science and its objective views of analysis (Riggs, 2004; Gorelick, 2014). The more scientific view may perceive this personal relationship and view as a bias, preventing the falsifiability of the science; however, as I will explain in the criteria this is not quite the case. Science may find the uncharted territory of cultural understanding unnerving, while Indigenous knowledge holders do not want to risk the possibility that this aspect of their understanding to be lost or misused (Maragia, 2006). Acknowledging the contributions made by Indigenous peoples and their cultural practices towards innovation in environmental studies and modern medicines may increase the desire to collaborate with IK and for IK and science to be successfully integrated (Clarkson, 1992; Battiste, 2003).

Language

The literature identifies two parts to a language barrier— a translational barrier limiting the transfer of all information and— a barrier in the way each form of knowledge chooses to use their language, which I describe as 'mode of research' below. Language can act to exclude those not part of a community or group of people. This is the case in sciences as well as IK; however, neither is considered intentional (Mitchell, 2018). In western science, publications in top journals are often based on a specific lexicon leaving those who do not know it unable to access that information and make connections (Drew & Henne, 2006). Aikenhead (2001) explains how

translation from Indigenous languages forces words to be distorted and meaning removed; he provides an example: “English/Cree dictionaries, for instance, distort Aboriginal knowledge by forcing the 13 moons into 12 months”. Kimmerer (2013) also explains this well in the chapter *Learning the Grammar of Animacy*. She describes how Indigenous languages are verb based rather than noun based. Each word tends to contain a deeper understanding than giving a name for something or categorizing it. Traditional languages will contain details in words that describe something for its qualities and behaviors (Aikenhead, 2001; Kimmerer, 2013). In both cases we must be mindful that the thing we are referring to can change dramatically between languages and the lack of perspective can leave both sides at a loss as to how to achieve thoughtful communication (Riggs, 2004).

Governance

One of the most significant barriers impeding the success of current collaborations designed to integrate IK and science is the extent to which Indigenous peoples and organizations are being involved in and considered at the research and management levels (Riggs, 2004; Gorelick, 2014). Many organizations are currently required to consult with local Indigenous communities; however, that is where the involvement tends to end (Schmidt & Stricker, 2010; Semeniuk, 2019). Successful integration of IK and science requires Indigenous involvement that occurs from the beginning and that shares decision making to facilitate greater success and increase validity (Finn, Herne, & Castille, 2017). IK contains a depth of information not considered with western science and should be considered not only as local understanding, but also as a perspective that can strengthen hypotheses and develop new ideas (Kimmerer, 2013; Snively & Williams, 2016; Brauer, 2017). Without viewing IK as a complex form of understanding and utilizing each of its aspects on every level of management and research, the

opinion of incorporating IK will not change and the integration of IK and science will produce less useful results (Riggs, 2004).

Mode of Research

Both Indigenous knowledge holders and western scientists analyze and study nature with the intent of understanding relationships among species and ecosystems and intricacies of natural history (Gorelick, 2014; Gauch Jr., 2003). Both question nature and develop a working understanding in the form of hypotheses; however, the way in which information is gathered and subsequently shared often differs (Wu, 2001; Snively & Williams, 2016). Indigenous knowledge is gathered in a more passive and observational way, often asking: “What can this species teach me?” or “What lesson can be learned from this phenomenon?” (Evering, 2012; Kimmerer, 2013). This way of viewing nature puts the observer and the observed on the same level as well as allowing the observer to form a relationship with the phenomenon. As a result the observer forms an understanding in a systemic and holistic way. As for western science, questions are often asked in a way that follows the scientific method’s predisposed boundaries and limits such as being testable and repeatable (Gauch Jr., 2003). That is not to say the scientific method is wrong but rather that it may limit perspectives and would benefit from incorporating other vantages that follow a complimentary research process (Riggs, 2004; Schmidt & Stricker, 2010). However, even with an understanding of the complimentary nature of the two research processes, a lack of trust and intensions may still prevent collaborations.

Historical Conflicts

Trust has held back integration of science and IK. Both current and historical lack of trust have built walls that must first be surmounted to allow effective collaboration. In addition to historical issues with trusting European settlers due to attempts to assimilate Indigenous people,

this mistrust extends to the misuse of IK by western science (Riggs, 2004). Past interactions between Western Science and Indigenous peoples tend to be from the observer - observed relation rather than as collaborators and peers with equal and relevant knowledge (Ferreira & Gendron, 2011) Interactions with researchers who have had false intentions further resulted in distrust and repercussions, such as collaborations ending with information being shared with government entities that exploited resources and information that were being maintained and protected by Indigenous groups (Aikenhead, 2001; Riggs, 2004; Kimmerer, 2013). Trust is also an issue – western science following its circumscribed methods has limited trust of IK and its methods, largely due to the lack of documented quantitative evidence in IK and western sciences inability to statistically validate findings from IK (Drew & Hanne, 2006; Schmidt & Stricker, 2010; Maragia, 2005; Bartlett, Marshall, & Marshall, 2012; Gorelick. 2014). Due to these issues, some western scientists do not believe that IK is relevant to modern society and today's ecological challenges (Battiste, 2005; Maragia; 2006). Trust is a barrier that must be considered at all stages and from both parties in knowledge co-production with constant communication related to intentions and truthfulness of information. Without trust the integration of the two fields will not be possible.

Criteria

The barriers provide us with an understanding of what is limiting collaborations as well as where to focus future efforts. From the document analysis of the literature selected for review, I developed a list of criteria to help overcome the barriers and efficiently integrate IK and western science. This list overlaps with some of the main barriers; however, it is considered from the forward-thinking perspective to advance collaborative relationships. The criteria are as

follows and considered from both Indigenous and western views:

1. Accept new perspectives.

Diverse perspectives need to be considered to grasp relevant and complex issues, perspectives such as IK, but also the humanities and seeing humans and their relationships with nature as an implicit part of local ecosystems and biodiversity (Maragia, 2006; Bartlett, Marshall, & Marshall, 2012). These perspectives should be used where they will strengthen scientific inquiry and boost the effectiveness of management (Huntington, 2000).

2. Maintain cultural considerations.

Indigenous knowledge is inherently linked to culture. To truly benefit from IK, culture must be considered to access the information it stores (Schmidt & Stricker, 2010; Aikenhead, 2001). Indigenous culture adds a deeper level of perception to nature that western science misses and would strengthen place-based understanding in field studies (Cajete 2000; Riggs, 2004). Culture is maintained in the language through stories, songs, and community which must be considered for their factual information also the analogies and metaphors that conceptualize the complexity of nature for the proper transmission of IK (Cajete, 2000; Gorelick 2014).

3. Find common ground.

To benefit both knowledge bases, we must determine areas where IK and western science are similar and how one might compliment the study of the other in certain areas (Bartlett, Marshall, & Marshall, 2012). Indigenous knowledge has been renowned for its understanding of nature and various environmental management practices (Aikenhead,

2001; Schmidt & Stricker, 2010). Seeing this as a base to develop trust and identify other areas of common goals or techniques will benefit future collaborations (Drew & Henne, 2006).

4. Include in all level of management and research processes.

Including IK in development of monitoring policies, management practices, and throughout the research process will help strengthen bonds between groups as well as build an understanding of each others' techniques and ideas (Riggs, 2004; Schmidt & Stricker, 2014). Through active partnerships, IK and western science will be able to create better informed and socially relevant management plans (Moller et. al., 2004; Maragia, 2006).

5. Maintain a high level of scientific inquiry and falsifiable truth.

Both IK and Western science have a common goal to understand the complexity of nature, albeit through different perspectives (Drew & Henne, 2006). Striving to validate facts, these perspectives should reinforce each other to find a common truth (Schmidt & Stricker, 2010; Bartlett, Marshall, & Marshall, 2012). Findings should be held in question by both parties and analysed as falsifiable data. Historically some individuals have been known to “make it up” knowing they’re knowledge will not be taken serious and therefore a high level scrutiny should always be maintained (Bartlett, Marshall, & Marshall, 2012).

6. Meet in the field.

IK ultimately stems from its relationship with nature and should be used and supported for its understanding of local ecology by using and sharing it in the field. Monitoring projects have benefited from active partnerships with local Indigenous communities and consideration of their local knowledge (Gadgil, Berkes, Folke, 1993; Huntington 2000). Incorporating this knowledge and understanding has provided previously unknown connections and data points that have changed the outcome of research (Huntington, 2000; Schmidt & Stricker, 2010). Similar to finding common ground, meeting in the field provides an area where both knowledge systems can contribute and be supported to the fullest.

7. Have a multi-disciplinary understanding.

To integrate both science and IK, an in depth understanding and respect of both knowledge systems must first be obtained (Aikenhead, 2001). Observing IK through a western lens usually causes it to be considered abstract (Gorelick, 2014). This can be addressed by being willing to learn and observe through different approaches and disciplines (Riggs, 2004; Drew & Henne, 2010). Bartlett, Marshall, & Marshall (2012) describe this using the Mik'maw's "two eyed seeing" analogy, described as viewing a topic through the perspective of both knowledge systems or "both eyes".

8. Understand the history

Understanding what has happened in the past, both positive and negative, will allow us to build on positive cases and learn from negative ones (Aikenhead, 2001). IK is imbedded in the history of the people and the culture they follow (Daes, 2008; Huntington, 2000).

To understand it in all its complexity, one must first be immersed in the past that has developed the information over long time periods for large systems (Riggs, 2004).

Methods

There is little research done in the area of integrating Indigenous knowledge and science through the work of biological field stations/place-based research organizations. Because of this, I used an exploratory case-based approach to collect information through multiple case studies primarily using social studies approaches. The findings are mainly qualitative using document analysis and interviews. Qualitative research is defined as research collected in a non-numeric way (Baxter & Jack, 2008). Yin (2003) describes case study research as answering the “why” and “how” without manipulating the subject largely through observational analysis. A multiple-case study approach is an extension of case study research where multiple cases are built and then compared and contrasted to further strengthen the thesis (Braun & Clarke, 2006).

Multiple Case Study Design

A multiple-case study research design was used following Baxter & Jack (2008) and Yin (2003). Twelve cases were initially screened and the top five were used in the analysis. These five were chosen through discussions with my supervisors and subjective assessment of relevance to my thesis through criteria outlined in the literature review. Information availability was also considered in the selection process. My thesis is bounded using a space-activity method of boundary determination (scoping) (Yin, 2003). Boundaries are used as inclusion and exclusion criteria for qualitative sample selection that keep the extent and complexity of the study on topic (Baxter & Jack, 2008). These boundaries were set using the following guidelines:

1. *Is the case relevant to the main study area and local Indigenous groups? (in or near Southern Ontario)*

2. *Does the organization conduct research or engage in conservation management? To what extent?*
3. *How involved is the Indigenous group/community in the field station/research organization?*
4. *Are their approaches ethical?*
5. *Do they address any or all of the criteria outlined in the literature review?*

Cases were analyzed to address the issues found in the literature review (see Chapter 2).

The criteria extracted from the literature and personal experience/discussions helped keep the study within the defined boundaries and guide the analysis of each case with the specific purpose of allowing common themes between cases to emerge (Baxter & Jack, 2008). Common themes found between cases informed the findings, answering my first objective: “How is IK used by field stations and place-based research institutes, and how is it or is it not being integrated with western science?”

Literature Review Document Analysis

The literature review provided the first step in the analysis process. I first discussed Indigenous Knowledge, Landscape Ecology, and Field Station/place-based research organization mandates and operations to give an understanding of how these themes overlap. The literature in these areas was analyzed using thematic analysis/document analysis, grouped to find common barriers that may prevent collaboration between practitioners of IK and western science. These barriers then informed criteria that were used to assess the selected cases and develop recommendations for improved integration of science and IK in current and future collaborations.

Case Development

Using a holistic multiple-case design, cases were developed through a range of sources such as documents, online information and interviews. I adopted Yin’s (2003) description of a

literal replication use of multiple-case study “to predict similar results” to compare similar themes among cases. Cases were developed from the following source types:

- organization websites;
- peer-reviewed journal articles;
- social media accounts;
- news articles;
- news video media;
- books; and
- interviews.

While building cases an in-depth analysis was conducted using Atlas.ti thematic analysis software, (ATLAS.Ti 8 ink, version 4.8.18, 2019). TA/DA is a form of qualitative analysis that organizes a dataset of documents that can then be easily broken down and compared to develop themes (Braun & Clarke, 2006). My dataset is made up of documents from the sources listed above for each of the five cases. Each document is broken down into codes. A code is a set of words that describes specific content found within a document. Each code is linked to the content allowing reference back to an explicit topic without having to revisit the literature.

Commonalities among codes allow grouping into master codes that describe the more general themes found across cases (Braun & Clarke, 2006). Braun & Clarke (2019) refer to this process as a cross-case synthesis. Developed themes were then oriented in a constructivist way, such that they focus on how a specific truth is shaped from the data (Braun & Clarke, 2019).

Interviews

Interviews were conducted in a semi-standardized manner following ethics guidelines set out by the General Ethics Research Board, Queen’s University pertaining to cultural, personal, and academic privacy. Semi-directive interviewing based on predetermined questions was carried

out. Questions were open-ended allowing the interviewee to share their opinions and ideas that might be missed in a fully structured interview (Berg, 2009). This form of interviewing allows the interviewer to address the interviewee in a language they will understand fully. Interviewees were chosen based on their role in specific cases such as the founder/director of the organization or Indigenous consultant/knowledge holder who from which the IK was obtained. Interviewees were asked a series of questions (Table 1) following Berg's (2009) format for a semi-structured interview. These questions addressed the criteria determined in the literature review along with preliminary themes developed in the DA.

Table 1. Interview questions used to guide semi-directive interview process.

Interview Questions:
<ul style="list-style-type: none"> • Please describe partnership research you have carried out with Indigenous communities/individuals in the past/currently.
<ul style="list-style-type: none"> • What are the main benefits you have experienced through this partnership research?
<ul style="list-style-type: none"> • What do you believe are the largest barriers to merging Indigenous knowledge with western science?
<ul style="list-style-type: none"> • Do you believe Field stations/research institutes are a good place for incorporation of Indigenous knowledge to occur? What other places/organizations might this take place
<ul style="list-style-type: none"> • What must be kept in mind when thinking about working with Indigenous knowledge?
<ul style="list-style-type: none"> • Are there similarities between western science and Indigenous knowledge that should be focused on?
<ul style="list-style-type: none"> • In some situations, e.g. some environmental assessment and environmental management, science data is considered primary data over Indigenous data. What are your thoughts on the relationship between these different knowledge sources?
<ul style="list-style-type: none"> • There are different aspects of Indigenous Knowledge (e.g. Elders (historical TEK), Hunters (current TEK), Women, Youth, Language...) What aspects are most valuable to you and your organization?

Results

Five cases were chosen through a subjective selection process (explained in the methods). All five cases are located in Canada, One in British Columbia and four in Ontario (Figure 2). Georgian Bay Biosphere Reserve (GBBR) located in Perry Sound, Ontario is a non-profit organization and part of a UNSECO biosphere reserve with the main goal of regional

sustainability in the Georgian Bay area. The organization works in partnership with multiple first nations communities, including Shawanaga First Nation and the Magnetawan First Nation, on community engaging sustainability workshops as well as assisting with community established monitoring programs (<http://gbr.ca>). Queens University Biological Station (QUBS) is located on Lake Opinicon in Elgin, Ontario. Part of Queens University, QUBS has a dual goal of educational and research excellence, recently taking initiative to incorporate IK in both aspects through including Mohawk/Anishinaabe languages in natural history education and working with local and northern communities on carrying out research projects. Haida Gwaii Institute (HGI) located in Haida Gwaii, British Columbia is a partnership between the community-developed Haida Gwaii Higher Education Society (HGHS) and University of British Columbia faculty of Forestry. HGI's focus is on education in natural resource management, sustainable economies, university education, and is in the process of establishing a research institute with a goal of Indigenous and community-engaged research. Turtle Island Conservation (TIC) is located in Toronto, Ontario as a part of the Toronto zoo, focusing on cultural awareness and natural history through Indigenous perspectives. The River Institute (RI) in Cornwall, Ontario is an organization dedicated to the monitoring and maintaining the health and biodiversity of the St. Lawrence River. In close partnership with the Mohawks of Akwesasne, RI conducts monitoring practices through a combination of IK and western science methods. Through document/thematic analysis and semi-structured interviews, I analyzed these five cases in regard to how they address some or all aspects of the criteria developed in the literature review. I explain below the work of the three cases (GGBR, QUBS, and HGI) that included interviews with respect to how they address the criteria. Without interviews, not enough information was gathered for the TIC and RI to provide an accurate breakdown of how their organization addresses each criterion (Figure 3).

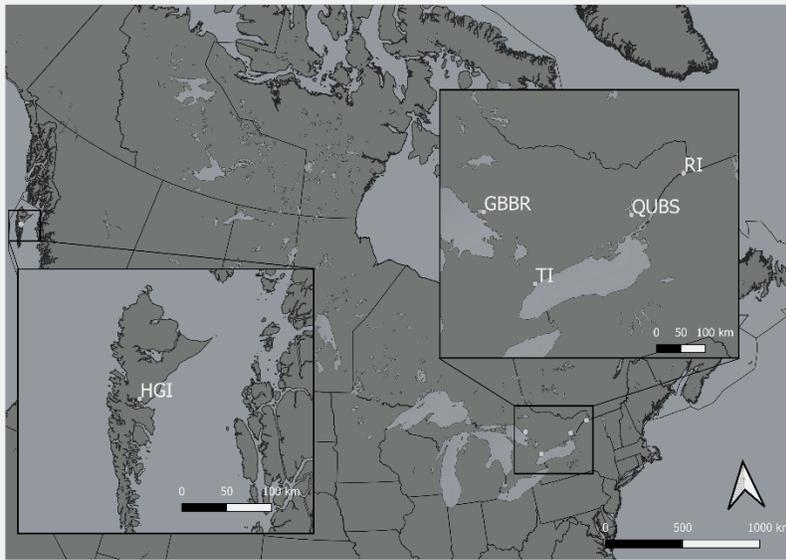


Figure 2. Map of Canada including the location of the five cases studied. HGI – Haida Gwaii Institute, GBBR – Georgian Bay Biosphere Reserve, TI – Turtle Island Conservation, QUBS – Queens University Biological Station, RI – River Institute. Dots represent the location of case site.

Case Study Results

Georgian Bay Biosphere Reserve

The document analysis for GBBR formed the largest portion of codes (n=88) with most relating to the criteria: accepting new perspectives (n=15), maintaining cultural consideration (n=15), and including in all levels of management and research (n=20). The other five criteria made up the remainder (n=38) (Figure 3).

Accepting New Perspectives

Accepting new perspectives, especially those of the local Indigenous communities, is important in the everyday practice of GBBR. In an interview with the Executive Director of the biosphere reserve, Dr. Rebecca Pollock, she explained that when working with their Indigenous partners they are “always asking how can we learn from you?” and from this practice of reciprocity and respect they are able to “gain a perspective and also give a perspective”. They

believe that each partner brings new information and expertise that is crucial in understanding and protecting such highly biodiverse habitats.

Maintaining a Cultural Consideration

In a article about reconciliation in the Georgian Bay Biosphere region, general manager Greg Mason exclaimed the “need for our BR to support two key activities: (1) promoting and supporting activities that build Indigenous communities and (2) activities that create bridges between communities to enhance reconciliation actions” (Judge & Mason 2018). The BR has proven that they support these activities among others while respecting their Anishinaabe partners. Kyla explained how important language is when working with the Indigenous groups: “all our values, beliefs and knowledge is in the language” and as a result the BR works hard at incorporating the language and culture into their projects and workshops such as birch bark canoe building or *wiigwaas-jiimaan*.

Finding Common Ground and Meeting in the Field

Finding common ground and meeting in the field accounted for a small number of codes, (n=4, n=6) respectively. However, it was clear through their initiatives that their partnerships were built of the common ground of sustaining the local wildlife for future generations. Kyla Judge, Indigenous youth coordinator for GBBR, said: “It starts with understanding the importance of sustaining and maintaining [fish] populations” while referring to the Shawanaga fish hatchery which maintains the last healthy walleye population in Ontario. While not directly part of the hatchery themselves, GBBR works closely with them in maintaining and monitoring fish stocks in the hatchery and in the Georgian Bay area.

Including in All Levels of Management and Research

GBBR works on multiple projects in close partnerships with local communities on multiple species at risk programs including a lake sturgeon conservation plan that is co-run by Shawanaga first nation as well as community outreach programs such as building *wiigwaas-jiimaan* (birch bark canoe), as mentioned earlier. Many other programs in action in the Georgian Bay area are initiated by the local first nations such as a walleye hatchery and a reptile and amphibian road mortality program. GBBR works with the nations on these projects to share new insights but also learn from them: “we’re here to learn, our western science might not have adequate frameworks to accommodate TEK and so it should be a humbling experience to observe and listen” (Rebecca Pollock). These programs highlight GBBR’s desire to engage with the community and be in constant dynamic relationship with their Indigenous and non-Indigenous partners and always asking how they can benefit the community as Dr. Pollock indicated: “My focus is always on communitiy engagement”.

Maintain a High Level of Scientific Inquiry and Falsifiable Truth

Through the programs mentioned above and many others it is clear that GBBR is constantly striving to set a standard in conservation practices. Shawanaga fish hatchery shares this quality while maintaining the one of the last healthy walleye population in the Great Lakes region. However, with constant uncertainty about the effectiveness of hatcheries, Shawanaga fish hatchery, with help from the BR, is constantly monitoring and ensuring the quality of the fry coming out of the hatchery. In addition to monitoring, Kyla Judge explained how the community has a “moratorium on fish catch - three fish per night per household” to help maintain the population as well as taking it one step futher by ensuring that every fifth year no fishing taking place to allow the stocks to replenish and for effective monitoring to occur.

Multi-disciplinary Understanding and Understanding the History

Dr. Pollock described the need for Interdisciplinary complex backgrounds to solve problems - “we have a rich depth of knowledge when we combine our experiences. We have ‘robust’ data to draw from”. GBBR works on their active relationships with the local first nations, Dr. Pollock pointed out the need for their knowledge to be held on the same level “there is a dominant and subordinate knowledge system [in Canada], and they are not treated equally. We’re on a path to push those barriers aside”. Understanding the history of relationships with first nations and in constant reconciliation, the BR strives to overcome this stigma and set the standard for work done with Indigenous partners. Through their projects and practices GBBR shows the importance of understanding the history and viewing IK as its own discipline is necessary as “... the models of western science are not always supportive of TEK” (Kyla Judge).

Queens University Biological Station

Queens University Biological Station (QUBS) has been a leading field research station for many years. Under the current director Dr. Stephen Lougheed, they are working on new goals of research with Indigenous partners as well as bringing more IK and culture to their station. As a result, there are few currently accessible documents and subsequent codes on their Indigenous engagement (n=36). Accepting new perspectives was the strongest criteria for QUBS (n=10) with maintaining a high level of scientific inquiry and falsifiable truth as the second (n=5). The other six criteria made up the remainder (n=21) (Figure 3).

Accepting new Perspectives

Dr. Lougheed has been at the forefront of research in the arctic looking at fish migration patterns and non-invasive polar bear monitoring, both of which are done in close partnership with Inuit communities to gain a perspective that is unique and unknown to his team, “IK is

associated with a long history of a particular land base – if you're not associated with this land you don't have the relationship with that land and miss a lot of the understanding" (Stephen Lougheed). Through this work among others, Dr. Lougheed has come to respect IK on a deeper level and is working on incorporating it more into his work both in research and management; however, he explained the difficulty in breaking down the hierarchical barriers in science to accept new perspectives. "Current collaborations have two views that are conflicting and most side with the scientific data and the IK is still correct but on a different scale and through a different perspective".

Maintaining a Cultural Consideration

A nation or communities' culture is maintained in their language and similarly is the knowledge they hold. Dr. Lougheed discussed the realized importance of this through his work with Inuit communities "There is not literal translation from the language, and it is its own fully developed knowledge system. Each community is onto itself – it cannot be generalized. Each has its own distinct traditions and knowledge bases." He explained how he is working on bringing this understanding to QUBS through a grant focused on indigenizing the elementary and highschool curriculum with the goal "to marry scientific and Indigenous perspectives into the same lesson plan and in the environment". A large portion of this project, he explains, will include installing multi-lingual signs around QUBS with Mohawk and Anishinaabe names and cultural importance of different species.

Common Ground and Meeting in the Field

IK is associated with a long history of an area and a deep respect and understanding of the local environment. Dr. Lougheed believed this is a huge common ground between naturalist and Indigenous people – "a deep relationship". He explained how individuals who work at field

stations for 20+ years have a relationship with the area, giving it an extra importance and understanding, “Similar kind of thing with biologists, it’s why I keep going back to all the places I keep going back to. I know them and love them”. These relationships may however be on different scales but a mutual relationship with nature that both Indigenous people and field biologists have may provide a good place to start.

Include in All Levels of Management and Research

Through current partnerships with Inuit communities, Dr. Lougheed and Queens biology department have been working on including communities in the management and direction of research, which is clear through their work in the arctic. Past research published on snake traditional ecological knowledge (TEK) in Sarnia, Ontario included the Aamjiwnaang TEK holder as a co-author. With a few examples of including IK and communities research, Dr. Lougheed strives to continue work with Indigenous groups and incorporate local nations knowledge and people into practices at QUBS and in his research in the near future.

Maintain a High level of Scientific Inquiry and Falsifiable Truth

Indigenous knowledge and western science can work together well if addressed properly. “It has to be a careful articulation of how they go together, and it has to be done with mutual respect, and there are already inherent biases in some scientists (including me)” said Dr. Lougheed when discussing the benefit of an adaptive management system. This system works to adapt programs with new incoming data and new information to keep the plan accurate and up to date. With an adaptive management system, Dr. Lougheed and QUBS plan to work with Indigenous communities to maintain an accurate log of the natural history around QUBS and continuing to make new discoveries while considering the unique perspectives of IK.

Multi-disciplinary Understanding and Understanding the History

When working with Indigenous knowledge, Dr. Lougheed discussed how they are their own knowledge system that brings their own information, “they may be complimentary, but they can’t be merged. One can inform the other and vice versa”. We must recognize them as separate and equal systems, however, “getting all the people on the same page will be quite challenging, and perhaps simply not possible”. Many western scientists are stuck in their current paradigm while Indigenous communities and individuals are hesitant to work with researchers due to historical exploitations of knowledge and lack of credit. We must work at these relationships and understand how they may work together and recognize the mistakes in the past that formed the current stigma.

Haida Gwaii Institute

The Haida Gwaii Institute is a leading example of Indigenous partnership in higher education. HGI is working on branching into the field of research bringing an immense understanding of partnership and respect for working with IK. Of the total codes made (n=51), cultural consideration was the highest code group (n=10), while accepting new perspectives (n=8) and maintaining a multi-disciplinary understanding (n=8) were the second highest with the same number of codes. The other five criteria made up the remainder (n=25) (Figure 3).

Accepting New Perspectives

HGI is built on extensive community contribution and work to employ local knowledge holders as teachers to share local information in courses such as ethnobotany and ethnoecology. Working on upholding the voice of the community and the knowledge they hold, Dr. Carlos Ormond, the director of HGI discussed the importance of “perspective approaches” in the work done at HGI, “Much of the courses are based on the Haida nations relationship with the land”. The Haida nation, as well as most Indigenous nations in Canada, are ‘system thinking’ such that

they are always considering the complex relations in nature. Being able to learn this perspective provides the students with new unique ways of viewing nature that a typical university program would not provide.

Maintaining Cultural Consideration

Respecting the culture of the Haida nation is a top priority of HGI and they work hard to ensure this done at all levels of their organization. Carrie Anne Vanderhoop, the Indigenous and community initiatives manager at HGI explained how “Indigenous knowledge needs to be up there in all levels. That being said there is knowledge that is meant to be held in communities” pointing out the sensitivity of some knowledge that needs to be respected and left in within the community. Dr. Ormond talked about the value of a gesture such as a ‘land acknowledgement’. As simple as it may seem, starting with acknowledging the specific territory or nation that you are on sets a standard of respect, especially for those who are new to the area. This is extended into their work as Carrie Anne mentioned, “The research that we’re involved in is around reconciliation and education” further demonstrating the importance and respect HGI has for the culture and values of their Indigenous partners.

Finding Common Ground and Meeting in the Field

Living among the community, Dr. Ormond exclaimed how HGI is close with its members, giving them a stronger understanding of relevant issue and goals, “Seeing mutual benefit of relationships, we’re colleagues but also community members and neighbors. We listen to the community and respond to the feedback and get guidance from the community”. This understanding helps HGI work with the community on areas of importance such as marine conservation and socio-ecological change through their ‘Haida Gwaii Semesters’. Their work allows students to gain hands on experience in community engagement and traditional

knowledge within their degree, “blending classroom instruction with field lectures, western science with traditional knowledge, and theoretical learning with experiential learning.”

(<http://hgoinstitute.ca/marineconservation>). Through the common goal of the community and the hands on initiatives of HGI, they are promoting future generations of natural resource managers, sustainable economies, and reconciliation that can be taught and applied elsewhere in Canada.

Include in All Levels of Management and Research Processes.

The Haida Gwaii Institute was built on the collaboration of the HGHES and the University of British Columbia to build a university program “based on the relationship with the Haida nation and the community” (Carrie Anne Vanderhoop). This relationship has promoted the constant engagement of the community in the work and decision-making done at HGI as Dr. Ormond pointed out “we have an MOU (memorandum of understanding) with the Council of the Haida Nation. We work to keep lines of communication open and a strong relationship with the community (organizations and people)”. The relationship HGI has with the Haida Nation extends past consulting with community. “Much of the courses are built alongside on the Haida Nation’s relationship to the land and sea” remarks Carrie Anne as she explained the role of community voice and community engagement in their programs “It engages local youth, Haida elders, weavers, carvers; provincial, federal and Haida government officials; industry workers, academics, scientists, and community members. This approach places participants in a living classroom” (<http://hgoinstitute.ca>). HGI is constantly striving to promote active partnerships with the Haida nation at all levels of their organization and is setting a standard for community engagement in University institutions.

Maintain a High Level of Scientific Inquiry and Falsifiable Truth.

Dr. Ormond and his team are working on creating a research center as an extension of the HGI. As a result, they have little active research but are working toward continuing their trend of community involvement into their research projects while maintaining credibility in both the scientific/academic fields and in the Haida community. Currently, HGI provides university level programs that engage students in a real time understanding of the environment such as their marine conservation and social-ecological change programs while gaining new perspectives and approaches to conservation through their Indigenous partners. These programs promote an understanding of real-time issue that can be applied to other environmental and social issues around Canada and possibly the world.

Multi-disciplinary Understanding and Understanding the History

The importance of a multidisciplinary work is clear at HGI, through their approach to teaching with both Indigenous and western teachers, as well as teaching through both scientific and social lenses; “to fostering a strong learning exchange between a diverse group of students, instructors, and community to share their experience and knowledge, in order to provide a very broad and balanced perspective on complex issues” (<http://hgoinstitute.ca>). Through this approach they are constantly reflecting and talking to the community about the history of academic work in the community and understanding how some past studies have been conducted without consulting with the community or respecting their knowledge. Carrie Anne explained the need for this respect when “understanding the culture and personal information, there is a sensitivity of knowledge extraction”. Through the approaches and practices at HGI, their organization is constantly working to understand their partners and collaborate with the community as equals with their own unique information to share.

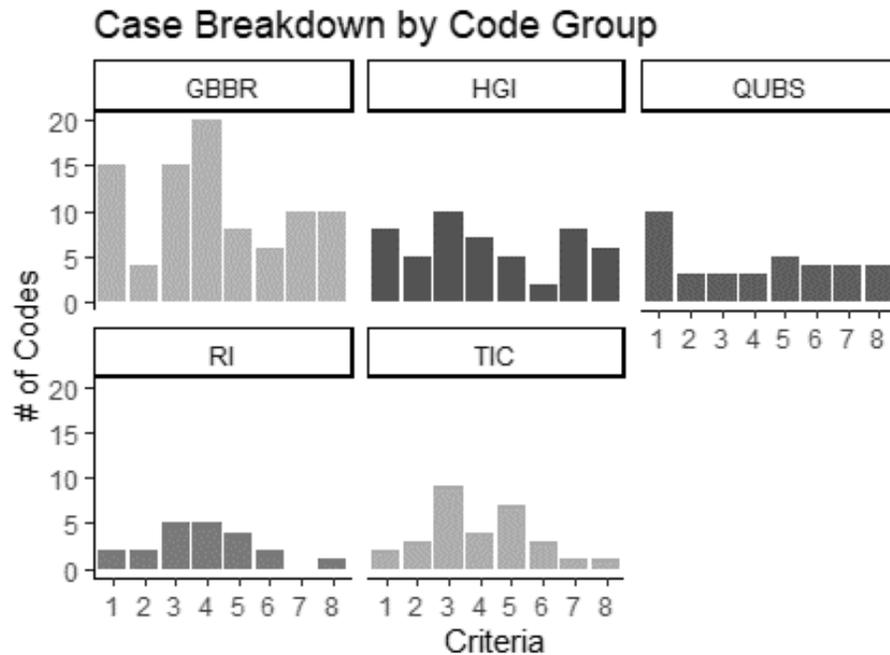


Figure 3. Bar plot of the criteria strength found through thematic analysis for each case. Number of codes depicts the strength of each criterion. Criteria are shown as numbers: 1- accepting new perspectives; 2- finding common ground; 3- maintaining a cultural consideration; 4- including in all levels of management and research; 5- maintaining a high level of scientific inquiry; 6- meet in the field; 7- multi-disciplinary understanding; 8- understanding the history. Cases are listed using their abbreviated names: Georgian Bay Biosphere Reserve (GBBR); Haida Gwaii Institute (HGI); Queens University Biological Station (QUBS); River Institute (RI); and Turtle Island conservation (TIC).

Discussion

There were two main objectives of this thesis: 1; Gather an understanding of how Indigenous knowledge is being incorporated in field stations and place-based research institutes along side western science, and 2; Identify strengths and weakness in practices to inform on how IK best fits into the work of field stations/place-based research institutes. These objectives were met, and an understanding was strengthened by the stepwise nature of the analysis process. By examining the literature and determining common barriers, I gained an understanding of practices that would promote healthier partnerships. These practices, in the form of criteria, were further contrasted against current organizations working with IK. This process implicitly

answered both objectives while providing supported results for how IK should be included in field station/ place-based research institutes.

Viewing this topic from different vantages altered my understanding and opinions –my study outlined flaws and lack of understanding in terms of the ‘integration’ of IK and western science. I originally focused on biological field stations when I concluded that there are little to no examples of strong partnerships (or documented partnerships) with Indigenous community at field stations. This led to the adaptation of the study to include place-based research institutes, which only broadened active partnerships slightly. Further, through my research and conversations, I realized the lack of respect for IK implicit in some of my own wording, specifically, referring to IK as ‘knowledge’ and not ‘science’ when comparing it to western science and looking at ‘incorporating’ IK which tends to reduce it to individual parts negating its ability to stand alone as a credible knowledge base. These realizations are evident in the progression of the paper into the results.

Of the eight criteria I developed through the literature review, three stood out in the case studies: *accepting new perspective, maintaining a cultural consideration, and including in all levels of management and research*. The cases analyzed shared these common criteria as the most important when working with Indigenous people and their knowledge. These criteria circled around the common idea of active partnerships, which came up in all interviews. The cases all saw their Indigenous partners as holders of untapped knowledge and were eager to learn. The desire to learn from new knowledge bases was highlighted through the accepting new perspectives criteria but was always complimented with an understanding and respect for the people and knowledge being shared. In the literature reviewed, authors consistently defended the legitimacy of IK, highlighted the misunderstanding of information due to a language barrier, and

emphasized the need to view nature at different spatial and temporal scales. The cases studied did not share these features as barriers but rather opportunities to broaden their knowledge bases and gain new insights and direction on research projects. This involved knowledge holders and community members often being on the board of directors or authors in research papers further promoting active and ongoing partnerships.

Conclusions and Future Research

To incorporate Indigenous knowledge into field stations and place-based research institutes a few key observations must be kept in mind: The knowledge has its own fact-based knowledge that cannot be understood fully without considering it in the context of a particular nation's culture. This requires an open mind and willingness to work with new perspectives and knowledge bases. Collaborations must be approached as two equal and complimentary entities with ideas from both implemented at every stage of planning and operation. This will foster a relationship between knowledge holders and western academics promoting an understanding and trust in the other knowledge base. Through active partnerships and adaptive management planning, current organizations have set standards for integrating Indigenous knowledge into field stations and place-based institutes monitoring and research.

The findings in my thesis should be useful in the management and planning of existing or new organizations considering integrating IK and science into both research and management. By using the criteria listed above as a guide when approaching collaborations, along with cases as examples of active and successful partnerships with their local Indigenous communities, these recommendations will enhance chances of success. My study focused mainly on the incorporation of IK into organizations management and practice. However, further queries could be undertaken on the methods for including IK into research processes as well as other areas in

environmental management such as national parks and education. With changes in modern practices, the application of technology may assist in collaborations between IK and western science. By engaging Indigenous youth through technology and the environment, their education in both knowledge bases may foster new ideas of collaboration and overlap that will benefit future of our environment and communities.

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Appendices

Websites of case studies:

www.gbbr.ca – Georgian Bay Biosphere Reserve

<http://qubs.ca> – Queens University Biological Station

<http://hgoinstitute.ca> – Haida Gwaii Institute

www.riverinstitute.ca – River Institute

<http://www.torontozoo.com/tz/tic> - Turtle Island Conservation

Useful links and examples not included in the paper:

https://works.bepress.com/shawn_wilson/

<https://fernwoodpublishing.ca/book/research-is-ceremony-shawn-wilson>

<http://www.integrativescience.ca/Principles/TwoEyedSeeing/>

https://books.google.ca/books?hl=en&lr=&id=VIGncLGEf5MC&oi=fnd&pg=PR5&dq=grenier+1998&ots=gqEiAV9HME&sig=-9O-Q51EX1FMCaAxh8HACuVrhdY&redir_esc=y#v=onepage&q=grenier%201998&f=false

http://fnmieao.com/resources/PDF's/How_Indigenous_knowledge_advances_modern_science_and_technology.pdf